

WEEKLY NEWS IDEAS INNOVATION

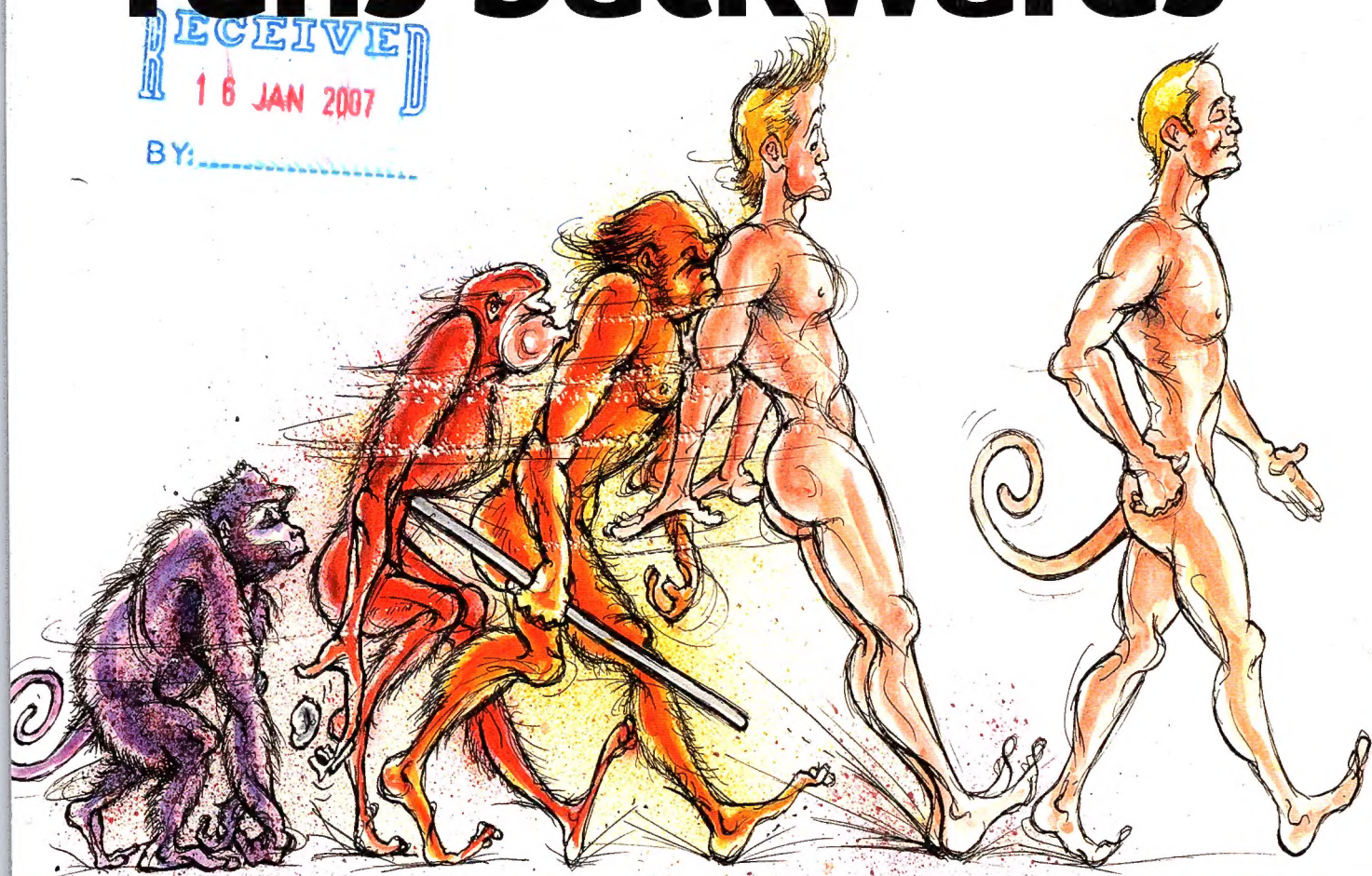
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When evolution runs backwards

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Australia
 REED BUSINESS INFORMATION
 ACN 000 146 921
 Tower 2, 475 Victoria Ave, Chatswood,
 Sydney, NSW 2067, Australia,
 Tel +61 2 9422 2999 Fax +61 2 9422 2725

UK
 Lacon House, 84 Theobald's Road,
 London, WC1X 8NS
 Tel +44 (0) 20 7611 1200
 Fax +44 (0) 20 7611 1250

USA
 600 Technology Square, Cambridge,
 MA 02139
 Tel +1 617 386 2190 Fax +1 617 397 2805

201 Mission Street, 26th Floor,
 San Francisco, CA 94105
 Tel +1 415 908 3348 Fax +1 415 704 3125

Publisher Sunita Harrington

Marketing and PR Coordinator
 Nicole Scott Tel +61 2 9422 2893
 nicole@newscientist.com.au

National Advertising Manager
 David Pope Tel +61 2 9422 8854
 david@newscientist.com.au

Subscriptions Marketing Manager
 Alex Mackenzie
 Tel +61 2 9422 2244
 Alex@reedbusiness.com.au

Production Manager John De Fraia
 Tel +61 2 9422 2627 Fax +61 2 9422 2722
 production@newscientist.com.au

Graphic Designer Ronnie Lawrence
 Tel +61 2 9422 2742 Fax +61 2 9422 2722
 ronald.lawrence@reedbusiness.com.au

Australasian Editor Rachel Nowak
 Tel +61 3 9376 1546 Fax 03 9245 7511
 rnowak@newscientist.com.au
Sydney Emma Young
 emma.young@newscientist.com

Subscriptions
 Tel +61 2 9422 2666 Fax +61 2 9422 2633
 Australia only Toll Free 1300 360 126
 subscriptions@newscientist.com.au

Newsstand
 Gordon & Gotch Australia
 Customer Service: Tel 1300 650 666
 Fax 1300 650 777 (Australia only)
 Gordon & Gotch New Zealand Customer
 Service: Tel +64 9 625 3018
 callcentre@gordongotch.co.nz

Enquiries
 Tel +61 2 9422 2666 Fax +61 2 9422 2633
 Australia only Freecall 1300 360 126
 enquiries@newscientist.com.au

Syndication
 Tribune Media Services International
 Tel +44 20 7588 7588

Back Issues & Merchandise
 Tel +61 2 9422 2666 Fax +61 2 9422 2633
 Australia only Freecall 1300 360 126
 customerservice@newscientist.com.au

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 Australia
 Tel +61 2 9422 2666 Fax +61 2 9422 2633
 Australia only Freecall 1300 360 126
 enquiries@newscientist.com.au
 UK
 Tel +44 (0) 7611 1230
 enquiries@newscientist.com

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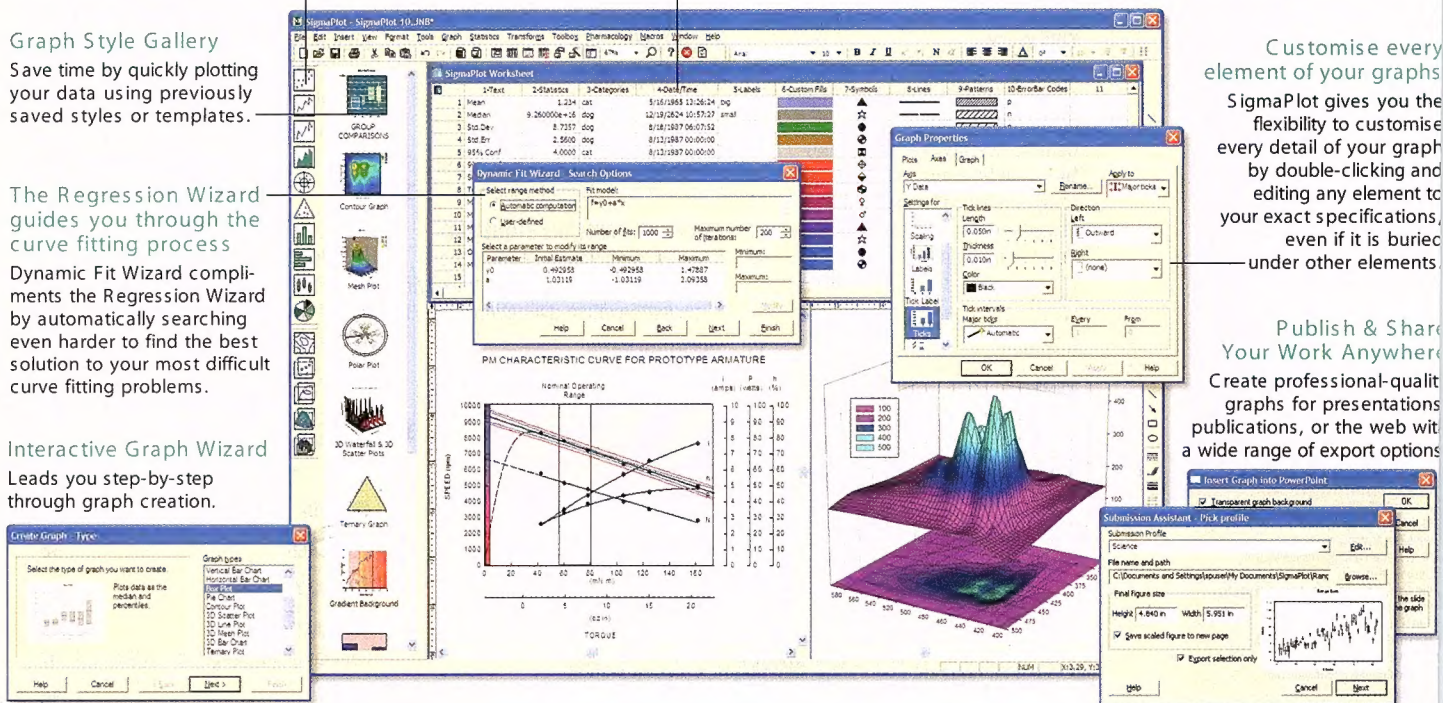
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Editor Jeremy Webb
 Personal Asst & Office Manager Anita Staff
 Associate Editors
 Liz Else, Stephanie Pain

News Editor Matt Walker
 Editors Linda Geddes, Rowan Hooper,
 Anil Ananthaswamy, Helen Night
 Tel +44 (0) 20 7611 1210
 Fax +44 (0) 20 7611 1280

Reporters
 LONDON Andy Coghlan, Hazel Muir,
 Paul Marks, Zeeya Merali
 news@newscientist.com

BOSTON
 US Bureau Chief Ivan Semeniuk
 David L. Chandler
 david.chandler@newscientist.com

Celeste Biever
 celeste.biever@newscientist.com
 Gregory T. Huang
 greg.huang@newscientist.com

SAN FRANCISCO
 Bureau Chief Peter Aldhous
 peter.aldhous@newscientist.com

TORONTO Allison Motluk
 toronto.office@newscientist.com
 BRUSSELS Debora MacKenzie
 brussels@newscientist.com

MELBOURNE
 Australasian Editor Rachel Nowak
 rnowak@newscientist.com.au

Features Editors Ben Crystall,
 Kate Douglas, Clare Wilson, David Cohen,
 Graham Lawton, Valerie Jamieson,
 Michael Le Page, Caroline Williams
 Features Assistant Celia Guthrie
 Tel +44 (0) 20 7611 1230
 Fax +44 (0) 20 7611 1280
 features@newscientist.com

Opinion
 Senior Editor Michael Bond
 Editors John Hoyland, Amanda Gelter,
 Alison George

Opinion Coordinator Eleanor Case
 Tel +44 (0) 20 7611 1240
 Fax +44 (0) 20 7611 1280
 opinion@newscientist.com
 Researcher Lucy Middleton
 Editorial Assistant Nick Christensen

Production Editor Mick O'Hare
 Asst Production Editor Melanie Green

Chief Sub John Liebmann
 Subeditors Vivienne Greig, Ben Longstaff,
 Julia Brown, Barbara Kiser

Art Editor Alison Lawn
 Design Craig Mackie, David Knight,
 Michelle Olosu
 Graphics Nigel Hawtin, Dave Johnston
 Pictures Adam Goff, Ludvine Morel
 Tel +44 (0) 20 7611 1268
 Fax +44 (0) 20 7611 1250

Careers Editor Richard Fisher
 careers@newscientist.com
 Tel +44 (0) 20 7611 1248
 Fax +44 (0) 20 7611 1280

Consultants Alun Anderson, Barry Fox,
 Stephen Battersby, Marcus Chown,
 Michael Brooks, Fred Pearce, Rob Edwards,
 Mick Hamer, Justin Mullins, Ian Stewart,
 Gail Vines, Jeff Hecht, Helen Phillips,
 Gabrielle Walker, Richard Ffith,
 Bob Holmes, Emma Young

Press Office
 UK Claire Bowles
 Tel +44 (0) 20 7611 1210 Fax 7611 1280
 US Office
 Tel +1 617 386 2190

NEWSCIENTIST.COM
 Online Publisher John MacFarlane
 Online Editor Damian Carrington
 Deputy Online Editor Shaoni
 Bhattacharya, Gaia Vince
 Editors Maggie McKee, Will Knight
 Reporters Tom Simonite, Roxanne Khamis,
 Kelly Young, David Shiga, Catherine Brahic
 webnews@newscientist.com
 Special Reports Editor John Pickrell
 Online Subeditor Sean O'Neill
 Web team Neela Das, Ashis Joshi,
 Michael Suzuki, Cathy Tollet, Ruth Turner,
 Vivienne Griffith, Rohan Creasey

Forever young

Can stunting the growth of a disabled child ever be a good thing?

FEW people in the past week can have missed the extraordinary story of a 9-year-old girl named Ashley. Ashley's brain will always function at the level of an infant and she is bedridden. To help them cope with Ashley, her parents chose to stunt her growth with hormones and to remove her uterus and developing breasts. Debate has raged over whether Ashley's parents have violated her rights and stripped her of her dignity simply for their own convenience (see page 6).

There is no doubt that these interventions are extreme. Some have reacted with a feeling of revulsion. But as the debate unfolded it became clear that Ashley's best interests were uppermost in her parents' minds. Her quality of life is defined by her levels of comfort and interaction with others. Each intervention was chosen to increase one or both these factors.

Ashley's parents consulted several doctors and presented their case to an ethical panel of some 40 professionals. Doctors foresee potential benefits for Ashley and no serious long-term risks from the treatment: certainly none that would exceed the health risks she faces from being bedridden.

It is true that Ashley's parents made choices for her. But Ashley cannot make them herself, and will never be able to do so. She is profoundly disabled: unable to communicate

or even to hold up her head. If there were a chance she would ever be able to choose to enter a relationship and bear children, the debate would be very different, but that is not how Ashley's life will be.

Some people have objected to Ashley's treatment on the grounds that it starts us down the slippery slope to a world where parents can make their own lives easier by imposing medical or surgical procedures on their children. This is precisely why society needs ethical panels or court-appointed advocates to ensure that children's interests remain top priority. By publishing Ashley's story, her doctors have provided a template for how such oversight can be carried out.

Still, there is a yawning gap in the decision-making process. We do not know if bedridden people with profound mental impairment who are short and light live happier lives than their taller, heavier peers. Only randomised controlled trials will answer that question. Surgeons in particular need to overcome their resistance to subjecting surgical procedures to such rigorous testing.

Until such trials take place, Ashley's treatment will stay an inconclusive experiment: whether it will make her life better than it would otherwise have been will remain a matter of opinion. ●

I spy with my little eye

ASTRONOMY was once a purely visual science. It began with people gazing up at the night sky in wonder and evolved into an optical quest to understand what photons can tell us about the universe. These days astronomers have expanded their quest into the realm of the unseen, where unknown forms of matter and energy are not only hard to see, but by definition invisible.

This new brand of astronomy demands much from our imaginations and often challenges common sense: that which we cannot perceive is hardest to accept. Throughout the history of science, invisible entities such as the Copernican heliocentric solar system, atoms and black holes all made long, gradual transitions from theoretical constructs to things that everyone can comfortably accept as "real". In each case,

the key was to settle on the right image. Just think of an atom, for example, and hey presto, a picture springs to mind.

If visualisation is the road to reality then dark matter has travelled a long way this week. A 3D map has given us a vivid image of what the universe would look like if we could all don dark-matter glasses (see page 4 and <http://space.newscientist.com/article/dn10903>). The map is important to science because it tracks how the distribution of dark matter has evolved over time from smooth to clumpy, and confirms dark matter's role as the scaffolding around which visible stars and galaxies congregate.

What may prove to be more influential, however, is the way the map turns dark matter into something concrete for the eye. As the saying goes, seeing is believing. ●

Upfront



Shivering in the tropics

HOT 'N' COLD

As North Americans basked in a January heat wave last weekend, people in Bangladesh were freezing to death.

Across the world, the media reported sunbathing New Yorkers enjoying temperatures that topped 18 °C, up from the usual January daily maximum of 3 °C. But there were fewer stories about how residents in the Bangladeshi capital of Dhaka were enduring temperatures that fell from the daily average of 18 °C to between 5 and 8 °C. The government called on affluent people to donate warm clothes and blankets to the poor, as doctors reported that more than 100 people had died from the sudden cold.

Meteorologists suspect the extreme US weather was caused by the North Atlantic Oscillation, a distant cousin of El Niño. In Bangladesh, cold air sweeping in from Tibet was compounded by dense smog that prevented the sun warming the ground – smog made all the denser as people burned fuel to keep warm.

Waist of words

"THE buttocks are full, but her waist is narrow, the one for whom the sun shines." So runs a telling epithet from more than 3000 years ago describing Queen Nefertari, the favourite wife of the Egyptian king Ramses II. Telling, because it reveals that the writer intuitively knew what modern biology has since demonstrated – that a narrow waist is the most visible proven hallmark of health and fertility in women.

Now, by screening historical literature from the UK, India and China, researchers have shown

and 1799 for references to various bodily features and found the waist had most entries. "There were 66 romantic descriptions, and every one of them referred to narrow waist," they write in *Proceedings of the Royal Society B* (DOI: 10.1098/rspb.2006.0239). The same pattern emerged in 6th-century Chinese poetry and 1st and 3rd-century Indian literature.

Spinning drinks

CONFUSED by conflicting advice on nutrition? Perhaps it's best to ignore conclusions drawn from studies backed by the beverage industry. It seems that corporate funding of research into non-alcoholic drinks may bias findings in favour of manufacturers' products.

Since funding from the drug industry is known to bias published research, David Ludwig of the Children's Hospital Boston wondered whether the same was true for studies of nutrition. He focused on the beverage industry, which is often blamed for promoting obesity, diabetes and poor dental health.

Ludwig's team examined 206 scientific papers on the health effects of soft drinks, fruit juice and milk, 111 of which declared their funding source. They found that industry-backed papers were more than seven times as likely to produce a conclusion favouring a company's product (*PLoS Medicine*, DOI: 10.1371/journal.pmed.0040005).

The reasons for the bias are unclear, but could include a failure to publish unfavourable findings, or a tendency for firms to back studies likely to show their products in a positive light.

Ludwig says governments should invest more in nutritional research as a public health measure to counter industry bias. "It's a poor trade-off to save money on research and base nutritional policy on a flawed scientific database," he argues.

Perils of freedom

BEING released from prison may be far riskier than anyone thought. Former inmates of Washington state prisons were 3.5 times more likely to die during their first two years after release than people of the same age, sex and race who had never been incarcerated.

The danger was greatest during the first two weeks, when former inmates were 13 times more likely to die than their non-incarcerated peers (*The New England Journal of Medicine*, vol 356, p 157).

The study tracked 30,237

"For centuries, writers and poets have cited narrow waists as a mark of beauty"

that for centuries, writers and poets have cited narrow waists more often than any other bodily feature as a mark of beauty.

Devendra Singh of the University of Texas, Austin, and his colleagues screened works of English literature between 1501



He's so narrow-minded

former inmates released between July 1999 and December 2003. Leading causes of death included drug overdose and suicide, which the team believe may be due to prior addictions, underlying mental illness and the stress of re-entry into society.

Lead author Ingrid Binswanger of the University of Colorado, Denver, says additional services such as halfway houses and drug-treatment programmes may be needed. "If these results are applicable to other states and federal prisons, the implications would be staggering," she says.

Canyon tall tales

THE Grand Canyon was formed a few thousand years ago by Noah's flood, and not a few million years ago by geological forces, right? So says a glossy book still on sale in Grand Canyon National Park, despite scientists' protests.

The National Park Service has been promising to reconsider whether to sell the book since 2003 (*New Scientist*, 9 July 2005, p 8), but an investigation by the

"By selling the book the park is breaking its own rules by appearing to support religion"

Washington DC-based pressure group Public Employees for Environmental Responsibility discovered that the review hasn't happened. PEER also charges the NPS with blocking the publication of a pamphlet which describes creationism as non-scientific and advises park rangers how to distinguish science from religion in explaining geology to the public.

NPS spokesman David Barna compares the park's bookshops to a public library, with books on "many alternative beliefs", adding "it is not our role to tell people what to believe".

However, PEER director Jeff Ruch says that by selling the book, the government-funded park is breaking its own rules by appearing to support a religion.

Boson in range

THE Higgs particle just got a bit lighter, and the race to find it a little tighter, thanks to the most precise measurement yet of the mass of the W boson.

Physicists at the Collider Detector at Fermilab (CDF) near Chicago announced on Monday that the W boson – one of the particles that mediate the weak nuclear force – has a mass of 80.413 gigaelectronvolts (GeV).

The standard model of particle physics links the masses of W boson, the "top" quark and the Higgs boson. Using the newly measured mass of the W and the already well-known mass of the top quark, the team recalculated the predicted mass of the elusive Higgs, which is thought to give all

other particles their mass. The upper limit for the mass of the Higgs is now 153 GeV, down from the previous limit of 166 GeV.

Physicists already know that the Higgs is heavier than 114 GeV, because searches up to that energy have found nothing.

Until now, the Large Hadron Collider at CERN near Geneva, due to start working later this year, was the firm favourite to find the Higgs. But the lighter Higgs is well within the range of the Tevatron collider running at Fermilab. "For us at the Tevatron and CDF, it is very good news," says Mark Lancaster, CDF team member at University College London.

If the colliders do not find the Higgs at these energies, physicists will be forced to look beyond the standard model.

A 3D LOOK AT THE DARK STUFF

We can't even see dark matter, but that's proved no obstacle in compiling the first ever 3D map showing its distribution in the universe.

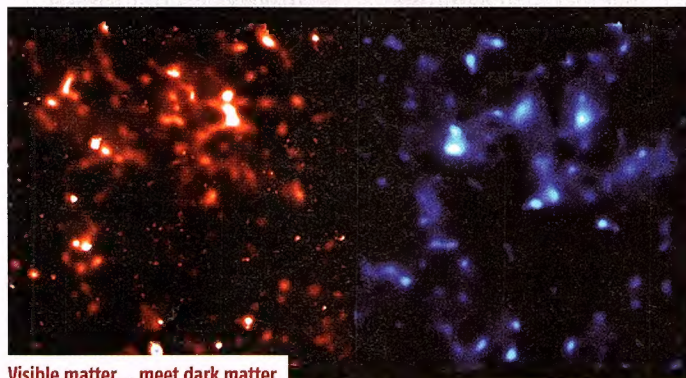
Using gravitational lensing – the bending of light from distant galaxies by the gravity of intervening matter – an international team mapped out the dark matter stretching halfway back to the birth of the universe. Data from the Hubble Space Telescope's Cosmic Evolution Survey (COSMOS), led by Nick Scoville of the California Institute of Technology in Pasadena, played a starring role. COSMOS studied a wide swathe of the sky, equal to nine times the area of the full moon.

To make the map 3D, the astronomers combined the COSMOS data

with data on distance derived from red shift measurements of galaxies from the Very Large Telescope in Chile and other images from telescopes in Hawaii.

The results validate theories of how structures such as galaxies formed and grew over billions of years, says Richard Ellis of Caltech, who worked on COSMOS. "We've seen that dark matter has grown in clumpiness over time," he says. This, in turn, attracts ordinary matter, which then clumps together to form galaxies and galaxy clusters.

But the map has some worrying anomalies – regions where there is dark matter but no visible matter and vice versa. The team attribute these to measurement errors, given that the instruments are working at their limits.



Visible matter... meet dark matter

Return ticket to space

The Indian Space Research Organisation was set to launch its first recoverable space capsule on 10 January from its launch site in Sriharikota.

The 550-kilogram capsule, which will carry experiments to be performed in microgravity, will stay in orbit for up to 30 days before splashing down in the Bay of Bengal.

A thinner dog's dinner

A drug specifically designed to treat canine obesity has been approved by the US Food and Drug Administration. Slentrol comes in liquid form and can be added to the pet's food. It appears to work by reducing fat absorption and making the dog feel full. Its developer, Pfizer, says it is not suitable for human use.

Biting back against rabies

The World Health Organization is launching a \$10 million, five-year plan to combat rabies. Announced on Wednesday, the initiative will increase the supply of drugs to treat the disease in developing countries in Asia and Africa, where 99 per cent of all cases are recorded. The disease is mainly transmitted by dog bites. The plan will also seek to increase supplies of treatments for snake bites and scorpion stings.

Google to hunt dark matter

Google is to help search for dark matter and dark energy. Last week, it joined the collaboration building the Large Synoptic Survey Telescope (LSST), due to see first light in 2013. The 8.4-metre LSST will generate 30 terabytes of data each night as it scans the skies, and Google will help organise this data.

Milk spoils tea party

Adding milk to tea may blunt its cardiovascular benefits. A study of 16 volunteers published in the *European Heart Journal* suggests that the effects of catechins – ingredients in tea thought to combat heart disease by dilating blood vessels – were blocked by casein proteins in milk.

This week Ashley's story

ASHLEY/REUTERS/DAVID J. PHILLIPS



Ashley is not the only one

Operating in whose interest?

Using surgery to improve the quality of a disabled child's life is common. Discussing it openly is not

JESSICA MARSHALL

SOMETHING about Ashley, the severely disabled 9-year-old American girl, has touched a nerve in the US and beyond. For more than two years she has been receiving high doses of hormones to stunt her growth, and she has had radical surgery to remove her breast buds and uterus to ensure she does not mature sexually.

Ashley's parents insist these measures are for her benefit – that they will enhance her quality of

life while they continue to care for her in their own home. Others accuse them of subjecting their daughter to potentially dangerous treatments for their own convenience, and denying her what they say is her right to grow up. There is unlikely to be a definitive answer, but the debate has shed unexpected light on the dilemmas facing those responsible for the welfare of severely disabled children.

Ashley's case is unprecedented in that the precise combination of

hormones and surgical interventions she was given have never before been documented in medical literature (see "An infant forever"), although doctors have previously used hormones to limit the growth of particularly tall teenage girls. This means the decision to intervene had to be taken without clear evidence of exactly how this package would affect her prospects. "There really is no solid evidence to suggest what the right thing to do is, or to confirm that it has had the desired outcome," says Robert Sade of the Medical University of South Carolina in Charleston.

This, however, is a frequent problem. "It is probably true of about 90 per cent of what we do in medicine," says Sade.

The urgency and complexity of many surgical procedures mean they are often carried out without evidence to inform the decision whether to go ahead.

A study published last month found just eight prospective randomised controlled studies – the gold standard for most clinical trials – out of a total of 135 studies published in the journals *Archives of Surgery*, *Surgery*, and *Annals of Surgery* over three months (*Journal of the American College of Surgeons*, vol 203, p 827).

In other respects, too, Ashley's case may not be unique. Alan Rogol, a paediatric endocrinologist at the University of Virginia, Charlottesville, says he knows of at least two other instances in which high doses of oestrogen have been used to halt a disabled child's growth. There are also precedents for the hysterectomy performed on Ashley. Bioethicist and paediatrician Douglas Diekema of the Children's Hospital and Regional Medical Center in Seattle, Washington, where Ashley was treated, says it is

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"In at least two other instances, high doses of oestrogen have been used to halt a disabled child's growth"

not uncommon for families to seek hysterectomies for girls in Ashley's position, though in many states this cannot be done without court approval.

Less severe interventions to improve the quality of life of disabled children are relatively common. For children with a cleft palate, surgery can improve their speech. Cosmetic repairs to a cleft lip are also routine. Parents of children with Down's syndrome or Beckwith-Wiedemann syndrome sometimes have them undergo tongue reduction, for functional and cosmetic reasons. "It is uncontroversial to improve quality of life," says paediatrician Chris Feudtner of The Children's Hospital of Philadelphia. Operations on disabled children to correct excessive drool are another example.

Ashley's case attracted only limited public attention in October 2006, when the doctors

involved published details of her treatment and the decision-making process behind it in the journal *Archives of Pediatrics & Adolescent Medicine* (vol 160, p 1013). It was not until Ashley's parents went public and posted their experiences on a blog (www.ashleytreatment.spaces.live.com/blog) on 2 January that the wider world became fully aware of it and began to debate their decision.

In most cases like Ashley's, the decisions are rarely held up for public inspection because in the US they typically involve only doctors and parents, though things can be different elsewhere (see "When caring costs too much"). Where the intervention is considered to be research, federal law requires it to be overseen by the review board of the hospital or university concerned. Most cases involving individual children are not classified as research, however, and ethics committees such as the one at Seattle Children's Hospital that discussed Ashley's treatment vary in terms of how often they are used and what authority they have.

"Very few ethical committees

actually have a power of decision-making," Sade says, and they usually try to keep the decisions in the hands of the parents. "We really only take the rights away when what the parents want to do constitutes child abuse," says David Magnus, a bioethicist at Stanford University in California. It is often a judgement call as to whether such a committee should be consulted. "Any surgeon at any time can decide to do a procedure on somebody," depending on an institution's guidelines for novel procedures, Diekema says.

In Ashley's case, the review process and the circumstances that led those caring for her to decide she was an appropriate candidate for the treatment she received have been laid out for all to see. "It's admirable they were so public," says Feudtner, even though he expressed reservations over the experimental nature of her treatment in an editorial accompanying the publication of her case (*Archives of Pediatrics & Adolescent Medicine*, vol 160, p 1077). "You want the debate to be in public." ●

Additional reporting by Linda Geddes

AN INFANT FOREVER

Ashley has been severely disabled since shortly after birth and is thought unlikely ever to be able to function beyond the level of an infant. Aged 9, she can't sit up or hold a toy, or even recognise her family. The source of her disability is a condition called static encephalopathy, or unchanging brain damage, the cause of which is unknown.

Yet Ashley is expected to have a normal lifespan, and for this reason her parents argue that she will be better off if she stays small. Because this will make her easier to move, she will be moved more often and taken along on more family outings, they say. She will be less likely to develop bedsores and other health problems. They also suggest that a small body may be a more appropriate match for her mental age.

Whatever the rights or wrongs of Ashley's medical treatment, it is already over. For two-and-a-half years she has worn contraceptive skin patches that delivered high doses of oestrogen. This triggered early puberty and the fusion of growth plates in her bones, so they stopped growing. At the end of the treatment a few weeks ago, X-rays showed that she had the bone age of a 15-year-old. At 135 centimetres tall, she is estimated to be some 33 centimetres shorter than she would otherwise have been as an adult, and is about 23 kilograms lighter.

The removal of Ashley's uterus will prevent the bleeding and potential discomfort of menstruation, and remove the risk of pregnancy were Ashley to be sexually assaulted by a future caregiver – as has happened to some severely disabled women in care. The removal of her breast buds – the beginnings of breast growth – was justified on the grounds that many women in her family have large breasts, which might have caused Ashley discomfort and made it difficult to strap her into a wheelchair. These procedures also mean she will not suffer the high risk of breast or uterine cancer that the hormone treatment would normally cause. Ashley's ovaries remain in her body and the oestrogen they produce will protect against osteoporosis, though her inability to bear weight as a result of her disability may still weaken her bones.

WHEN CARING COSTS TOO MUCH

"Why are loving parents being put in the position where they have to consider this type of treatment?" asks paediatrician Chris Feudtner of The Children's Hospital of Philadelphia. In some cases, it comes down to the resources the family can call on.

In the US, public healthcare provision rests largely in the hands of individual states. When families need special equipment – such as a hospital-type bed, bathing equipment, or a lifting harness – to care for someone like Ashley, they face a scramble to find resources. "The system isn't rational," Feudtner says. "You've got to know Dave at the Department of Whatever, and if you don't know Dave, you're screwed."

Even tougher is finding qualified caregivers to offer relief to the families in their own homes. "We have a home-care crisis in this country," Feudtner says. In their blog, Ashley's parents

write: "We tried hard and found it impossible to find qualified, trustworthy and affordable care providers."

Parents of profoundly disabled children like Ashley see the future bearing down on them "like a slow-moving freight train", says Feudtner. "The child is getting older, the parents are getting older. You see it coming down the track." When parents can no longer cope, their child is placed in a state or private long-term care facility. While state and federal funding through Medicaid, and any health insurance, may help, the costs can still reduce a family to poverty.

The situation is likely to be better in the UK, where free healthcare, social support and educational provision for disabled children are guaranteed by law. How much better depends on which part of the country you live in, says David Congdon, head of policy at the learning-disability charity Mencap, since access to

social service provision varies from region to region. "It's a real battle to get what you want," he says.

In the UK, looking after children with learning disabilities costs the state around £4.5 billion a year – excluding the costs of special education. The most expensive outcome of all is if the child has to go into permanent care, which costs up to £200,000 a year. Whether cost considerations would ever be used to justify giving a British child similar treatment to Ashley's remains an open question. "The whole concept would be contingent on the best interests of the child," says Richard Parnell of SCOPE, a charity supporting people with cerebral palsy. Under UK law, the welfare of the child is paramount, so parents would have to have a strong case for the intervention to avoid a legal challenge by the state on the child's behalf. Additional reporting by Andy Coghlan

A subtle key to human diversity

ANDY COGLAN

ANY article containing the words "race" and "genetics" tends to be controversial, and any scientific study researching the links between these concepts more so. Now a study of people of European, Chinese and Japanese descent has revealed distinctive patterns of gene activity in the different groups.

Critics of similar studies have long argued that it makes no scientific sense to link race and genetics, and not just because of the spectre of eugenics it evokes. The differences between the genomes of people of different ethnic origin are startlingly small, and what variation does exist is

greater between individuals than between ethnic groups.

Though the new study's findings do not fundamentally change this, geneticists agree that the details we are learning about how genes are expressed in different ethnic groups could have huge medical benefits.

Richard Spielman at the University of Pennsylvania, Philadelphia, and colleagues examined gene activity in a particular type of white blood cell called a lymphoblastoid. These cells contain some 4000-odd working genes when active in the body, out of the 23,000 or so genes in the entire human genome. Of 4197 genes the team studied, Europeans and Chinese

expressed 939 at significantly different levels, with Europeans and Japanese expressing 756 differently. Chinese and Japanese people expressed just 27 genes to significantly differing degrees. For most of these genes, the difference in activity between ethnic groups was less than twofold, though one gene, *UGT2B17*, was 22 times as active on average in European as in Asian carriers (*Nature Genetics*, DOI: 10.1038/ng1955).

Spielman and his colleagues declined to discuss the implications with journalists, including those from *New Scientist*, but other geneticists say the results tally with what we know about the way the simple differences in DNA called single nucleotide polymorphisms or SNPs (pronounced "snips") occur in different groups. In 11 genes Spielman studied in extra detail, a higher level of activity was associated with the presence of a SNP that switches the particular

gene on, providing more evidence of how tiny changes in the basic DNA code can significantly affect the expression of whole genes.

"It all hangs together," says Matt Hurles of the Wellcome Trust Sanger Institute in Cambridge, UK. "We knew that genetic variation is distributed unequally between populations and now we know it influences gene expression," he says. "It's nice to get this confirmation."

Stephen Scherer, a geneticist at the Hospital for Sick Children in Toronto, Canada, agrees. He wonders whether differing patterns of gene expression might also correlate with newly discovered differences in DNA known as copy-number variable (CNV) regions, in which genes are either missing or present as

"The details we are learning about gene expression in different ethnic groups could have huge medical benefits"

multiple copies. One indication that this might be the case is that *UGT2B17*, the gene that is expressed most differently between the ethnic groups, is known to be missing in four out of five Asians compared to one in five Europeans.

The next step, says Hurles, who co-discovered CNVs with Scherer and many others, is to test other cells to see if levels of expression vary as much in other tissues. A wider range of ethnic groups should also be tested, he says.

Other geneticists stress the medical benefits that could flow from such research. For example, populations that differ in their susceptibility to diseases such as type 2 diabetes and high blood pressure also carry different SNPs, says Alkes Price of Harvard Medical School. So biologists might be able to link these SNP differences to the activities of specific genes and target those genes with drugs. "Although the results are not surprising, the ramifications for disease genetics are quite significant," he says. ●



The same but different

“It exterminates thousands and forces them not to eat or drink, and they will have to evacuate their homes without taking anything with them, until we can finally purge them.”

Saddam Hussein, recorded on a tape played on Monday in Baghdad at the trial of his cousin, “Chemical Ali” Hassan al-Majeed, who is accused of plotting the 1988 chemical attacks on Iraqi Kurds (Reuters, 8 January)

“‘Plutoed’ has been chosen as 2006 word of the year.”

The **American Dialect Society** on 5 January, after Pluto last year lost its status as a planet. “Plutoed” means to demote or devalue (CNN, 7 January)

“The pilgrims come to wash away their sins. After a dip here, they may carry skin diseases with them.”

The Ganges is now too dirty for ritual bathing, warns **Hari Chaitanya Brahmachari**, who runs the Hindu monastery in Varanasi, India (AFP, 8 January)

“Tony Blair is crossing his fingers and hoping someone will invent aeroplanes that don’t cause climate change. That’s like holding out for cigarettes that don’t cause cancer.”

Emily Armistead of Greenpeace UK reflects on Blair’s view that energy-efficient air travel, rather than fewer flights, is the best way to limit greenhouse gas emissions from aircraft (*The Guardian*, London, 9 January)

“The baby was born on New Year’s Day.”

Vibhu Prakash, principal scientist at the Bombay Natural History Society, India, announcing the first captive birth of an oriental white-backed vulture. Numbers in the wild have crashed by 97 per cent because of poisoning by the livestock drug diclofenac (AFP, 9 January)



Bathed in stem cells

Amniotic fluid supplies 'repair kit' for later life

MOTHERS could bank a reserve of spare tissue for their child at birth now that stem cells have been discovered in the amniotic fluid surrounding infants in the womb.

Alternatively, cells from many babies could be stored in a public tissue bank. The huge number of samples on tap would mean that almost every patient would be able to find a match if they needed “off-the-peg” tissue.

The cells, termed amniotic fluid-derived stem (AFS) cells, appear to be “halfway houses” between embryonic stem cells (ESCs), primitive cells in embryos capable of turning into every cell in the body, and adult stem cells, partially differentiated cells dispersed around the body which replenish and repair specific tissues during life.

“They have the properties of both,” says Anthony Atala, head of the team that isolated and tested the AFS cells at Wake Forest University School of Medicine in Winston-Salem, North Carolina. “So far, we’ve shown they can grow into nerve, blood vessels, liver cells, cartilage,

bone and cardiac muscle,” he says.

AFS cells could supply a ready source of stem cells for therapeutic treatments. Doctors could either extract the cells from amniotic fluid sampled for prenatal testing, or from the placenta once the mother had given birth. The cells could then be preserved in liquid nitrogen – theoretically, for years. If the individual later needed a tissue or organ transplant, the cells could be grown into a perfect graft which the body wouldn’t reject.

At least that’s the theory. So far Atala has shown that AFS cells grow into almost as many types of tissue as ESCs, and just as quickly – doubling in number within 36 hours. Equally encouraging, nerve cells created from human AFC cells successfully integrated with brain cells in mice, suggesting the technique could potentially repair tissue in humans.

“So far we’ve shown these stem cells can grow into nerve, blood vessels, liver cells, cartilage, bone and cardiac muscle”

Other researchers welcomed the findings, published online in *Nature Biotechnology* (DOI: 10.1038/nbt1274). “If the cells can be extracted from the placenta, it’s a very convenient way of getting large numbers of cell lines that repair all types of cells,” says Ian Wilmut of the University of Edinburgh, UK, who was part of the team that created Dolly, the first cloned sheep.

“It’s likely that therapies will arise from cells like these way before they’re available from embryonic stem cells,” adds Lyle Armstrong of the University of Newcastle upon Tyne, UK. A separate team at Newcastle has been working with similar cells found in umbilical cord blood, which have the potential to mature into a smaller range of tissues.

The discovery of AFS cells doesn’t make ESCs redundant, however. ESCs are controversial because so far the only way to collect them is by destroying early embryos. But all the teams insist that ESCs will be invaluable, especially for understanding diseases and testing new drugs. Wilmut, Armstrong and a third team led by Stephen Minger of King’s College London were expected to hear this week whether their application to generate ESCs from “cow-human” or “rabbit-human” embryos in the UK has been successful. ●

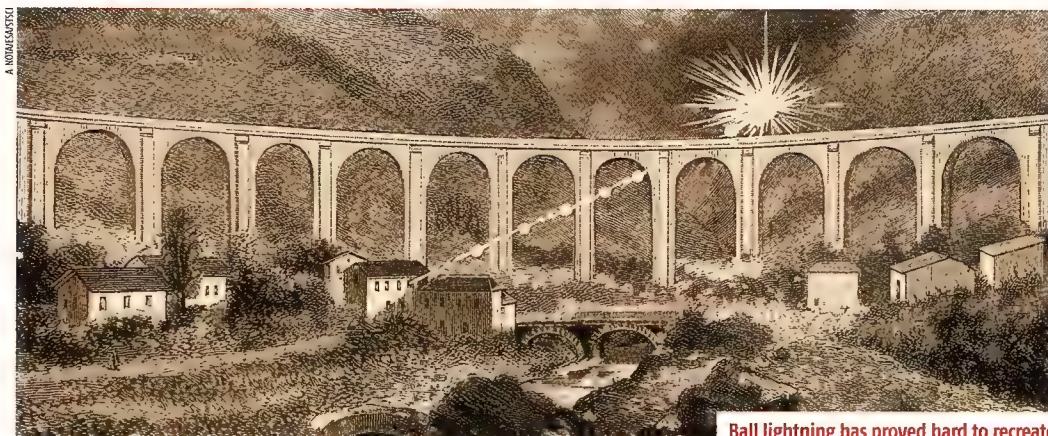


Volkswagen TDI Performance. Surprisingly Diesel.

When you drive any car from the Volkswagen TDI range the abundant torque makes acceleration exhilarating, hills a breeze and traffic simple to negotiate. Visit your nearest Volkswagen dealer to register for a test drive and experience the turbo diesel TDI technology for yourself. It delivers excellent fuel economy and outstanding performance from, surprisingly, diesel. But then perhaps it's not quite so surprising, after all it is Volkswagen.



Aus Liebe zum Automobil



Ball lightning has proved hard to recreate

Could these be the right balls of fire?

HAZEL MUIR

BALL lightning could soon lose its status as a mystery, now that a team in Brazil has cooked up a simple recipe for making similar eerie orbs of light in the lab, even getting them to bounce around for several seconds.

Thousands of people have reported seeing ball lightning, a luminous sphere that sometimes appears during thunderstorms. It is typically the size of a grapefruit and lasts for a few seconds or minutes, sometimes hovering, even bouncing along the ground.

One eyewitness saw a glowing ball burn through the screen door of a house in Oregon, navigate down to the basement and wreck an old mangle, while in another report, a similar orb bounced on a Russian teacher's head more than 20 times before vanishing.

One theory suggests that ball lightning is a highly ionised blob

of plasma held together by its own magnetic fields, while an exotic explanation claims the cause is mini black holes created in the big bang (*New Scientist*, 23/30 December 2006, p 48).

A more down-to-earth theory, proposed by John Abrahamson and James Dinniss at the University of Canterbury in Christchurch, New Zealand, is that ball lightning forms when lightning strikes soil, turning any silica in the soil into pure silicon vapour. As the vapour cools, the silicon condenses into a floating aerosol bound into a ball by charges that gather on its surface, and it glows with the heat of silicon recombining with oxygen.

To test this idea, a team led by Antônio Pavão and Gerson Paiva from the Federal University of Pernambuco in Brazil took wafers of silicon just 350 micrometres thick, placed them between two electrodes and zapped them with currents of up to 140 amps. Then over a couple of seconds, they moved the electrodes slightly apart, creating an electrical arc that vaporised the silicon.

The arc spat out glowing fragments of silicon but also, sometimes, luminous orbs the size of ping-pong balls that

persisted for up to 8 seconds. "The luminous balls seem to be alive," says Pavão. He says their fuzzy surfaces emitted little jets that seemed to jerk them forward or sideways, as well as smoke trails that formed spiral shapes, suggesting the balls were spinning. From their blue-white or orange-white colour, Pavão's team estimates that they have a temperature of roughly 2000 kelvin. The balls were able to melt plastic, and one even burned a hole in Paiva's jeans (see www.espacociencia.pe.gov.br/multimedia.ph).

These are by far the longest-lived glowing balls ever made in the lab. Earlier experiments using microwaves created luminous balls, but they disappeared milliseconds after the microwaves were switched off (*New Scientist*, 11 February 2006, p 16).

"The lifetimes of our fireballs are about a hundred or more times higher than that obtained by microwaves," says Pavão, whose findings will appear in *Physical Review Letters*. Abrahamson is thrilled. "It made my year when I heard about it," he says. "The balls, although still small, lasted long enough to come into the mainstream of observed natural ball lightning."

Pavão's team is currently working out the chemical reactions involved in the balls' formation, and experimenting with other materials that might work too, including pure metals, alloys and sulphur compounds. ●

THIS WEEK 50 YEARS AGO

Golden age of railways?

FOG has played its annual puckish part in upsetting the carefully planned timetables of British Railways.

It seems odd that trains, which do not even need to be steered, may be worse affected by fog than road vehicles. Each slight dislocation of the railway timetable seems to spread like some infectious disease. The lateness of one train holds up others behind it, and the effect quickly escalates. Soon the dislocation has become a lusty disruption.

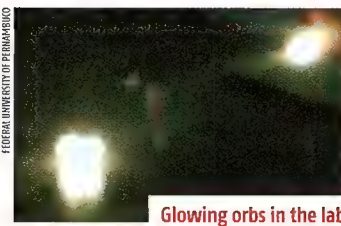
Passenger complaints are only a symptom of this – the true cost to the community is much larger. More than a million working hours may be lost in a single day as a result of the railways' inability to run trains to their timetables in a fog. Yet British Railways continues to use a method of controlling trains in fog that could hardly have been called advanced even in Victorian days.

When a fog is forecast, or when signalmen report to the traffic controllers at headquarters that it is foggy, the standard fog service is put into operation. This involves cancelling some trains to decrease traffic density. At the same time "fogmen" are called out to take up position at warning signals. Each is provided with detonators to fix on the line to give aural warning to the engine driver, a pair of flags, a lamp, and a coke brazier to keep them warm.

It is little wonder that the service is unable to maintain a steady flow of traffic over heavily used suburban rail lines. This is a ludicrous state of affairs. Automatic train control to alert drivers to the position of approaching signals already exists – is it not time to use it?

In these days of automatic pilots for aeroplanes and automatic helmsmen for ships, why is it still necessary to rely on the eye of an engine driver to pick out the shadowy form of a flickering wick in a signal lamp?

From *The New Scientist*,
17 January 1957



Glowing orbs in the lab

Speeding dwarfs upset galactic family picture

THE Milky Way's two best-known companions may be nothing more than strangers passing by. Recent observations of the Magellanic Clouds, a pair of nearby dwarf galaxies, reveal that they are moving too fast to be satellites of the Milky Way – unless our galaxy contains twice as much dark matter as thought.

Astronomers at the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts, and the Space Telescope Science Institute (STScI) in Baltimore, Maryland, compared Hubble Space Telescope images taken two years apart to make the most accurate measurements to date of the velocities of the Magellanic Clouds. During the two years, both galaxies had shifted a minuscule amount, about one-hundredth the width of one pixel in Hubble's field of view. The astronomers detected these tiny shifts by carefully aligning the clouds in each pair of images and then measuring the apparent change in the positions of several background quasars.

The astronomers used this information to calculate the clouds' true velocities through space, not just across our line of sight. This yielded figures of

378 kilometres per second and 302 km/s for the Large and Small Magellanic clouds respectively. If the two galaxies were orbiting the Milky Way – as many astronomers still believe – their velocities would have to be about 250 km/s. "I really wasn't expecting them to be moving so fast," says CfA's Nitya Kallivayalil.

If the clouds are not gravitationally bound to the Milky Way, astronomers will be hard pressed to explain the Magellanic stream – a river of neutral hydrogen gas that trails behind the Magellanic system and extends across more than a quarter of the night sky. "The stream implies a bound orbit," says Martin Weinberg of the University of Massachusetts, Amherst.

The alternative explanation, that the Milky Way contains far more dark matter than expected and so causes the dwarfs to orbit more rapidly, would be equally surprising but may prove easier to accommodate.

"They are moving too fast to be satellites of the Milky Way, unless our galaxy has twice as much dark matter as thought"

cell. In recent years, some theorists have used computational models to suggest that this noise helps organisms cope better with environmental stresses, but until now there has been little experimental evidence to back this up.

To fill that gap, researchers led by Jim Collins of Boston University took yeast and mutated a naturally noisy promoter sequence that controls the activity of a particular gene. By also tweaking the culture conditions, they created populations of engineered yeast cells in which the gene controlled by the promoter had the



Wisps that pass in the night?

Kallivayalil and her colleagues are also investigating whether a clumpy or otherwise asymmetrical distribution of dark matter within the Milky Way could account for the clouds' speedy motion. If such models prove unsuccessful, however, "then maybe we'll have to say the clouds are not bound," says

Roeland van der Marel of STScI.

In that case, says Kallivayalil, sky watchers on Earth will have approximately 3 billion years to enjoy the Magellanic Clouds before they fade from sight. The results were presented this week at a meeting of the American Astronomical Society in Seattle, Washington. **Ivan Semeniuk** ●

It pays to make a lot of noise if you're a gene

TO AN engineer, biological systems can look horribly sloppy. But when it comes to gene activity, a little sloppiness can be the key to survival.

Gene expression is a surprisingly "noisy" or variable process: even in a group of seemingly identical cells, there is often huge variation in the activity of a given gene from cell to

same average activity, but differed in its noise level. While the unmodified promoter caused bursts of activity in the gene, the mutated versions gave a slower, steadier response.

Next the researchers linked the natural and mutated promoters to an antibiotic resistance gene and inserted them into yeast cells. When they exposed the cells to the antibiotic, only cultures with the noisy unmodified promoter were able to grow (*Molecular Cell*, vol 24, p 853). They believe some cells in these cultures were able to overcome the antibiotic's effects thanks to

sudden spurts of gene expression.

Adam Arkin, a systems biologist at the University of California, Berkeley, is impressed with Collins's findings. "He takes a real engineering approach," says Arkin. Collins concedes that some biologists may question whether his engineered yeast cells are relevant to the natural situation, but he points out that the noisy promoters like the one he studied control genes that help yeast cells respond to environmental stresses. "Our underlying point is reflected in the natural genome," he says. **Peter Aldhous** ●

INSIGHT

Oil giants' money fuels a climate of suspicion

REMEMBER the days when tobacco companies denied there was a link between smoking and cancer? Litigation put an end to that, but the tactics live on elsewhere. The US Union of Concerned Scientists (UCS) says that misinformation and denial continue when it comes to global warming. This time it's the world's biggest company, ExxonMobil, that has been fingered as the bad guy.

UCS, a non-profit organisation based in Cambridge, Massachusetts, has published a 68-page report accusing ExxonMobil of exaggerating uncertainties over the causes of global warming. UCS says ExxonMobil has done this by funding 43 bodies critical of claims

of climate change, such as Frontiers of Freedom based in Washington DC, in the apparent expectation that these groups will propagate disinformation about global warming even when what they are publicising has been shown to be wrong.

"They gave life to views discredited by the scientific community," says the report's main author, Seth Shulman.

"Not a penny should be spent on this."

In fact the petroleum industry has spent rather more than a penny – ExxonMobil, for example, spent some \$16 million between 1998 and 2005, according to the report. In 1998 ExxonMobil-sponsored organisations promoted a report that said carbon dioxide



emissions posed no warming threat. The report was authored by, amongst others, Sallie Baliunas, an astrophysicist affiliated with at least nine ExxonMobil-funded groups. In 2003 Baliunas published a review paper in *Climate Research* (vol 23, p 89) claiming that the climate had not changed significantly in the past millennium. Her conclusions were

challenged by 13 of the scientists whose work she cited, but ExxonMobil-funded groups have continued to promote it.

ExxonMobil told *New Scientist* that the company does not control the views of the organisations it sponsors. "While there is more to learn on climate science, what is clear today is that greenhouse gas emissions are one of the factors that contribute to climate change and that the use of fossil fuels is a major source of these emissions," the company says.

David Read of the Royal Society in London says the debate about climate change must not be controlled by industry-funded lobby groups. "Given the tactics of many of these organisations to date, we should not be surprised if they redouble their efforts ahead of the publication of the Intergovernmental Panel on Climate Change fourth assessment report." The IPCC report is due next month. **Rowan Hooper** ●



In brief



Why the best dressed women have babies on their mind

DRESS to impress, goes the maxim. "Dress to conceive" might be more accurate. Women take greater care over their appearance when they are at peak levels of fertility.

Working with a group of 30 women aged 18 to 37, Martie Haselton of the University of California, Los Angeles, and colleagues took two full-body photographs of each woman, one close to ovulation when the woman was highly fertile, and one at a point of low fertility in the menstrual cycle. Volunteers were then invited to decide which of the two photos showed the woman trying to

look more attractive. They chose the woman in her "high fertility" photo some 59.5 per cent of the time more often than would be expected by chance (*Hormones and Behavior*, vol 51, p 40).

Though not in the same class as the obvious physical cues other primate females give when they are ovulating, it is the first evidence that women openly advertise their fertility. Interestingly, all the women in the study group described themselves as being in committed relationships with men. So why go to the trouble of dressing up? Perhaps to attract other men.

"Women with high fertility tend to feel attracted to men other than their primary partners," says Haselton. For the reasons why this might be so, see below...

How differences keep us together

NOT only do opposites attract, they also stay together. A couple's genetic differences seems to be the key to lasting happiness – a finding that could possibly lead to a DNA test revealing how likely a woman is to stay faithful.

Christine Garver-Apgar at the University of New Mexico, Albuquerque, and colleagues analysed genes belonging to the major histocompatibility

complex (MHC), which controls the way the immune system recognises invaders. Previous research has shown that the MHC plays a role in sexual attraction, but its lasting role in relationships had not been investigated.

Garver-Apgar analysed MHC genes from 48 heterosexual couples who had been together for at least two years and asked them how faithful and responsive

towards their partner they were.

For the women, the more similar their MHC was to their partner's, the less sexually responsive they were and the more likely they were to be attracted to other men and have affairs – particularly during fertile days of their menstrual cycle. Men seemed to be unaffected by MHC similarities (*Psychological Science*, vol 17, p 830).

The mechanism may have evolved to produce offspring with broad immunity to disease.

Cool for fossils

NATURE knows best when it comes to preserving ancient DNA. The DNA in fossils that are cleaned and preserved in museums degrades far faster than in bones left in the ground.

The extraction and sequencing of fossil DNA promises a wealth of information on extinct species. Yet little has been recovered from the most easily accessible sources, those in museum collections. To see why, Eva-Maria Geigl of the Jacques Monod Institute in Paris and colleagues compared DNA recovery from museum samples with those from freshly excavated fossils stored under conditions similar to natural burial. The fresh samples yielded six times as much DNA and twice the number of valid sequences as those from a museum (*Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.0610257104).

Geigl blames washing, chemicals and warm storage for the loss of DNA, and urges putting fresh samples in cold storage.

Send in the clots to kill off cancer

AN ARTIFICIAL scab could destroy tumours by cutting off their blood supply.

Nanoparticles have previously been used to target tumour blood vessels, but weren't particularly effective because only a small percentage stuck in the right spot.

Now Erkki Ruoslahti and his colleagues at the Burnham Institute for Medical Research in La Jolla, California, have produced nanoparticles with a built-in "self-amplifying" mechanism that in mice caused a three-fold increase in the number of particles that reach their target. The particles bind to the vessels and attract yet more particles and blood proteins, eventually causing a clot that blocks the vessel (*Proceedings of the National Academy of Sciences*, DOI: 10.1073_pnas.0610298104).

Barn swallows get broody while world warms

WARMER spring temperatures and a longer growing season are proving to be good news for barn swallows. Over the past 35 years these birds have responded to global warming by taking more time over rearing their chicks.

Around two-thirds of swallows produce two broods of chicks per year, one in April and another in July or August. Anders Møller from the Pierre and Marie Curie University in Paris has monitored barn swallows in the Kraghede region of northern Denmark since 1971, noting the date eggs were laid, and clutch and brood size.

Based on 2705 pairs of birds, Møller found that the time between clutches increased between 1971 and 2005. The birds started to breed earlier and gave themselves more time before the second brood. Timing between clutches increased by an average of 8 days (19 per cent) and swallows tended to produce more fledglings (*Behavioral Ecology*, DOI: 10.1093/behecol/arl051).

Møller believes that this relaxed breeding behaviour is down to climate change. Between 1971 and 2005 the mean April temperature in Denmark rose by 2.2 °C. The growing season, too, is longer.

"The [temperature] changes we are seeing today are much more rapid than in the past and the question is whether these birds will be able to keep up," says Stuart Bearhop, an ornithologist at the University of Exeter, UK.



PAUL VAN GAELENBERG

Memories are made of this molecule...

HOW are memories formed? The question has perplexed scientists for years, but now it seems we're a step closer to solving it.

The leading candidate is a process called long-term potentiation (LTP), in which the connections between individual brain cells get stronger the more often they are used, such as during learning. But while LTP has often been observed in slices of brain in the lab, it has been difficult to record in a living brain as learning was taking place.

Now Liliana Minichiello and

her colleagues at the European Molecular Biology Laboratory in Monterotondo, Italy, and the Pablo de Olavide University in Seville, Spain, appear to have done just that by isolating a molecule that initiates a signalling pathway for LTP in the brain of a living mouse. The finding builds on a technique they developed last year to record LTP in a mouse hippocampus – a brain region involved in learning – while the animal was being trained to blink in response to a tone.

In the new study, the team

used mice with a defective version of a receptor molecule called TrkB, found on the surface of brain cells in the hippocampus. The mice were unable to learn or initiate LTP in response to familiar stimuli, indicating TrkB is a key memory molecule. The finding will be published in *Learning and Memory* this week.

Minichiello hopes that as they identify more molecules involved in initiating LTP, this could pave the way for drugs to combat Alzheimer's disease, or to enhance memory capability generally.

Gravity gets a quantum boost

DESPITE its 300-year history, Newton's gravitational constant, G , is the least well measured of all the fundamental constants. Now quantum mechanics may help pin down the strength of gravity more precisely.

Traditionally, various kinds of torsion balance have been used to calculate G by measuring the twist in a wire induced by the gravitational force between two masses. But this can only provide rough estimates.

Mark Kasevich of Stanford University in California and colleagues split a beam of caesium atoms into two using an interferometer, then recombined them to produce interference fringes. A 540-kilogram lead weight placed near the beams shifted their paths and the interference pattern. The team used the shift to calculate a value for G , which matched that found by traditional methods (*Science*, vol 315, p 74).

This technique could one day yield the most accurate value of G . "We're seeing the gravity field in a purely quantum mechanical way, so we're free of the errors that limit the accuracy of traditional methods," says Kasevich.



R.S. COLETTI/REUTERS

Cold facts about ancient eruptions

YOU would expect that any evidence of how ancient volcanoes influenced Earth's climate went up in smoke long ago. Not so. It now seems that traces of past eruptions are locked up in the Antarctic ice, and can reveal if the plumes were massive enough to affect climate.

Volcanic particles that enter the stratosphere – the layer of Earth's atmosphere from about 10 to 50 kilometres up – undergo a distinctive reaction in the presence of intense ultraviolet light, affecting the ratios of sulphur isotopes that are eventually carried down to Earth as sulphate

compounds. Mélanie Baroni of Joseph Fourier University in St-Martin-d'Hères, France, and her colleagues studied volcanic particles in ice core samples from Antarctica, a region not contaminated by human emissions.

They detected two past eruptions that punched through into the stratosphere: the Philippines' Mount Pinatubo in 1991 and Indonesia's Mount Agung in 1963. Both eruptions affected Earth's climate by blocking out sunlight. Pinatubo is estimated to have cooled Earth by about 0.5 °C.

Now Baroni and her colleagues have drilled an ice core that dates back 1 million years, in order to find stratospheric eruptions. "It is helping us to work out the climatic impact these eruptions have," she says.

The curse of being different

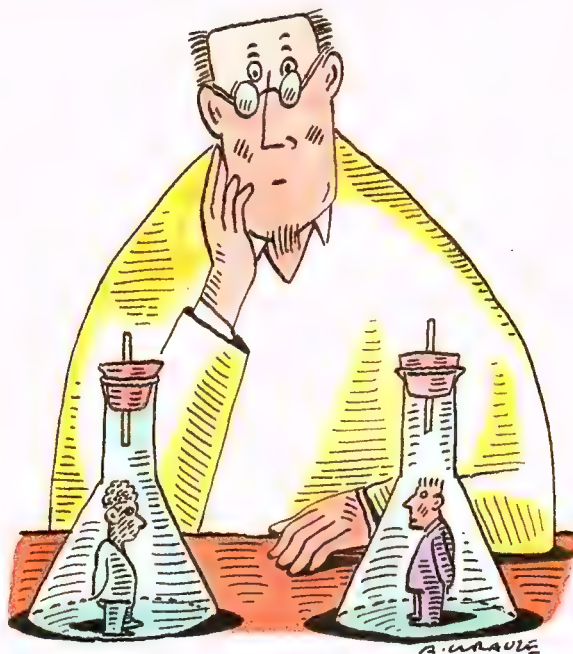
There's a simple way to combat the crippling effect of racial and gender stereotypes on students' performance. It's time to use it, says **Robert Adler**

THE achievement gap between white and non-white students – indeed between any marginalised group and the mainstream – is one of the most worrying and deep-seated problems in the US educational system. It is conspicuous from pre-school to college and has resisted decades of massive and costly educational reforms.

The problem stems in part from the stereotypes that society applies to such groups, which can make individuals painfully aware of how critically they are viewed and can have a crippling impact on their performance. Any situation that reinforces the stereotype – even something as simple as checking off one’s race or gender before a test – can threaten a person’s sense of themselves as good, competent and valued, which in turn raises anxiety.

For many African Americans, women and members of other marginalised groups, that anxiety can surge to performance-wrecking levels in class or during exams. Researchers have found that students who repeatedly encounter situations like this become frustrated and soon learn to avoid them. This is why many young women come to shun mathematics, sciences and engineering, and why so many African Americans disengage from academic pursuits entirely.

The good news is that psychologists are having considerable success tackling these problems, by developing simple interventions that strengthen students' social identities instead of threatening them. One of the most dramatic examples was demonstrated recently by social psychologist Geoff Cohen at the University of Colorado, Boulder (*Science*, vol 313, p 1307). Early in the school year, his team asked a group of African American 12 and 13-year-olds to spend a few minutes examining a list of values, based on things such as friendship and family, and to indicate which they felt were most important. The students then wrote a short paragraph explaining



why they felt the values they had chosen were meaningful to them.

This self-affirming exercise took just 15 minutes, yet it had a remarkable impact. Compared to their peers, these students showed more resilience in the face of failures and earned higher grades throughout the term. The exercise reduced the achievement gap between them and white students by 40 per cent. Given how deep-seated the racial achievement gap appears to be, this success seems astonishing. "It's a dramatic piece of evidence," says Claude Steele of Stanford University in California, who has devoted much of his career to trying to ameliorate the effects of negative stereotypes on stigmatised groups.

Other intervention experiments have had similar results. Between 2003 and 2006 Ilan Dar-Nimrod and Steven Heine at the University of British Columbia in Vancouver, Canada, tested the mathematical ability of 220 female college students (*Science*, vol 314, p 435). Before taking a maths test similar to one used by many colleges to screen

"It's like a switch releasing the motivations and abilities students had all along"

applicants to graduate programmes, some of the women read passages arguing that there are fixed gender differences in mathematical ability, while others read that differences in ability can be modified by experience. The researchers predicted that viewing ability as changeable would make it easier for women to overcome the negative stereotype that paints maths as a predominantly male pursuit.

They were right: the “changeable” intervention raised women’s maths scores by an astonishing 50 per cent. Carol Dweck, a psychologist at Stanford University who has developed a range of exercises that enable students from many different backgrounds to perform better, says that a number of recent studies show similar effects, “far beyond what you might expect from the simplicity of the interventions”. Julio Garcia at Yale University describes the techniques as a light switch that releases the motivation and abilities students had all along.

Clearly it is time to apply this approach more widely, though as the researchers point out it will not cure all the ills in the US educational system. The long-standing financial and structural problems also need to be addressed. "If the resources aren't there to begin with, this kind of intervention cannot work," says Cohen. "It won't teach a child to read or to spell."

While the structural problems may take decades to address, psychological interventions can help students today. “A key question is how to transform these scientific findings into something that can have widespread use,” says Jeffrey Hausdorff at Harvard Medical School. This could quickly be done. If dozens of small experiments had shown that a vaccine could protect children from a potentially crippling disease, it goes without saying that millions of dollars would be invested in large-scale studies and any successful treatment made universally available.

It is time to recognise that psychologists have developed just such a “vaccine”, with the potential to immunise young people against a condition that cripples the lives of millions. It’s high time we applied it. ●

Robert Adler is a psychologist and science writer who divides his time between Santa Rosa, California, and Oaxaca, Mexico

Good science will come

From Douglas Axe, Brendan Dixon and Ann Gauger, *Biologic Institute*
Your editorial asks a reasonable question: can the theory of intelligent design (ID) lead to good science (16 December 2006, p 5)? Researchers at the Biologic Institute are convinced it can. ID sceptics, of course, want proof.

We take that challenge seriously, which is why we insist on completing our research projects before talking about them. What you have interpreted as conspiratorial "caginess" is just scientific caution.

Your description of ID as doing nothing more than questioning Darwinism is incomplete. Cells process digital information. Humans have also developed this technology. Cells make molecular machines and complex materials by nano-fabrication. So do humans. Cells do complex chemistry, signal transduction and process control. So do humans. But Darwinism prevents what we have learned as engineers from illuminating biology, by insisting that the two modes of invention are fundamentally different.

What humans accomplish only by intellectual effort, nature puts to shame by mindless accident, we are told. If that is wrong – and we think it is – whole new fields open up, waiting to be explored. Perhaps neurobiologists would learn something from computer designers and network whizzes. Maybe systems biologists would start hanging out with systems engineers. We don't know where all this would lead, but we are confident that good science will come out of it.

Redmond, Washington, US

Investigating design

From Henry Law
Creationism is indeed worthy of serious investigation – as an exercise in social anthropology (16 December 2006, p 8). Adherents of Christianity and Judaism are not required to

believe in the literal truth of scripture. In order to do so, creationists must first accept that these texts came directly from God, which raises the immediate question of how they came into existence. Were they encapsulated in a rock, perhaps a meteorite? Did they arrive in the form of a celestial email, perhaps via a modem connected to the numinal realm – to the mind of the supreme creator who conjured a material cosmos into being from eternity?

If indeed they imagine they can know the divine mind in this way, then they are claiming an authority which exceeds that which their humanity allows them. Only the numinal can fully comprehend itself; as Saint Paul points out, "we see through a glass darkly".

We must ask, then, why groups of people are taking up such a position, especially in the light of two centuries of philology that has demonstrated the fluidity of language. One reason could be that it espouses a form of totalitarianism. In the light of the last century's examples of totalitarianism, study of the present creationist revival could well be rewarding.

Brighton, East Sussex, UK

From Bob Winters

Scientists have been typically moderate, patient and well-mannered with creationists. It is time to turn the tables and ask some hard questions of creationists and their theology.

If it is so easy to interpret the Bible, why are there so many Christian sects with different interpretations? If it were so critical to follow the Bible exactly, then the most important part of the Old Testament (and the easiest to interpret) would be the ten commandments. Why have Christians not kept the Sabbath (Saturday)? Does it mean that the only real believers are among those who do keep the Sabbath?

I suspect that the only thing a large number of very conservative Christians can agree on is

creationism. Could it be that creationism lacks any real theology, and that is why they can agree?
Sanctuary Lakes, Victoria, Australia

Creationism and reason

From Tony Braime

So it came to pass that creationism begat intelligent design which begat Discovery Institute which begat Biologic Institute (16 December 2006, p 8). It is amusing that a creed so dedicated to refuting Darwin is itself forced to undergo continual evolution.

Andover, Hampshire, UK

From Neil Paterson

There is a difficulty with the creationists' latest ploy to invest "intelligent design" with a veneer of scientific respectability by submitting their experimental work to peer-reviewed journals, which is that no scientific experiment can have any bearing on their hypothesis.

Intelligent design essentially claims that any biological system which has, at present, no compelling explanation in terms of the historical coming-together of functioning subsystems, may be taken as evidence that only an intelligent designer can account for such a system.

But when evolutionary explanations are found, the creationists shrug and move to the next currently unexplained system. This is the sure sign of pseudoscience – the hypothesis is permanently exempted from refutation by experience.

Dundee, Fife, UK

From Tom Corley

I feel compelled to compare your article "The God lab" with the polemic of the medieval Church against the scientific discoveries of the day. Any questioning of evolution is modern-day blasphemy and must be fought against.

Personally, I believe in evolution, but I say to the proponents of intelligent design:



do your research and publish your papers for peer review. If you manage to discredit evolution then you deserve a Nobel prize. *New Scientist* is supposed to be a magazine of science, and science is based on falsifiable theories. So let us see all scientific theories being open to being challenged and questioned. There are no sacred theories in science – so there is no place for scaremongering about anti-evolutionists. We should bid them work hard and prove us wrong.
Wotton-under-Edge, Gloucestershire, UK

From Ben Craig

Proponents of intelligent design are little different from the character O'Brien in George Orwell's 1984, who insists that "Whatever the Party holds to be the truth, is truth". In a democratic society, we risk becoming inundated with these false beliefs simply because we cannot prove them wrong: this risks losing democracy altogether.
Ware, Hertfordshire, UK

Beyond green ink

From Wolf Pascheles

Harry Collins really isn't helping when he lumps together "Martin Fleischmann (cold fusion), Eric Laithwaite (anomalous gyroscopes), Albert Einstein (relativity), Linus Pauling (vitamin C), Alfred Wegener (plate tectonics), Thomas Gold (origin of oil), David Duesberg (non-viral causes of AIDS), and Subrahmanyan Chandrasekhar

- Transport tax equity
- Wet simulation

(black holes)" (9 December 2006, p 46). All the higher-functioning purveyors of crackpot theories appear to believe that since they are laughed at, and since Wegener (for example) was laughed at, and Wegener was right, it follows that they are right.

Over the years I have taken an interest in the arguments about all of the examples Collins cites – as a literary phenomenon.

I suggest to Collins that there is a fundamental difference between these proposals, detectable before the scientific community has performed its testability rituals. That difference lies in their coherence – both internally and with others' work.

It is, for example, a feature of the loonier proposals that once you try to map out the details of the argument you find that long passages of minute and not-very-salient detail are interspersed with huge logical leaps on which enormous implications are hung. In other words, you don't need actual "green ink and no margins" to detect probable loonspudery. Those proposals that eventually pan out in the world are far more likely to exhibit narrative consistency – perhaps what Edward O. Wilson calls "consilience" in his book of that name.

London, UK



It's an ill wind...

From Martin Ashby

The main thing the report by the Renewable Energy Foundation proves is that statistics can be spun to support your case

(16 December 2006, p 7). Let us not forget the REF is a pressure group opposing onshore wind farms. The UK government's target for average productivity for wind is 30 per cent of theoretical maximum. "Average" means that some turbines will be below 30 per cent capacity and some above. The year chosen by the REF gives an average capacity factor of 28.4 per cent – or to put it another way: "Wind turbines hit government targets by 95 per cent in 2005!"

London, UK

Mitigating vCJD

From Kay Bagon

There is indeed great concern over the risk of an outbreak of vCJD in the UK from blood transfusions or infected surgical instruments (16 December 2006, p 7). In order to minimise the risk of vCJD, blood, plasma, cell and tissue products are now given only when they are essential to the survival of the patient, and the benefits are carefully weighed against the transmission risks.

In August 2002 the Department of Health announced that fresh frozen plasma for treating babies and young children born after 1 January 1996 would be obtained from the US (extended to all children under 16 years of age in summer 2005).

In December 2002 the Department of Health purchased independent US plasma collection firm Life Resources for over £50 million. This now supplies non-UK blood plasma for the manufacture of blood plasma products such as Factor VIII.

Since April 2004, blood donations have not been accepted from people who have themselves received a blood transfusion in the UK since 1980.

Such is the risk that many countries outside the UK including the US, Canada, New Zealand, Australia, Israel, Hong Kong, Germany, Switzerland, Austria and Ireland have taken the precautionary step of excluding all blood donors who

spent time in the UK between 1980 and 1996.

Radlett, Hertfordshire, UK

The editor writes:

● It is true that numerous measures have been implemented to minimise the transmission of vCJD in blood products. What the story highlights is that there is an unknown number of people who might already have been infected with vCJD by blood transfusions. They might have donated blood prior to 2004, and recent findings show that the infection spreads more efficiently this way than from eating infected meat.

Ulcers not by bugs alone

From Terry Baranski

Your interview with Barry Marshall makes it seem that it is now an accepted scientific fact that the bacterium *Helicobacter pylori* causes ulcers and stress does not (9 December 2006, p 53). Subsequent research has found otherwise.

See, for example, the *BMJ* review article (vol 316, p 538) which states: "*H. pylori* is inadequate as a sole explanation for peptic ulcers. Most people who harbour the organism never have ulcers, while a few who have never been infected with it or taken non-steroidal anti-inflammatory drugs develop ulcer disease."

Reston, Virginia, US

The editor writes:

● We have printed articles sceptical about *H. pylori*: see for instance www.newscientist.com/article/mg17123033.700-dead-man-walking.html (11 August 2001, p 30).

I don't believe it

From Roy Sablosky

The first four letters you printed on the "Beyond belief" conference (9 December 2006, p 24) invoke the "brilliant insight" that



atheism is itself a belief. This is rubbish, and *New Scientist* should not be promulgating it.

An atheist simply does not believe in any gods. By definition, this is not a belief. Just as nakedness is not a way of getting dressed; sleep is not a technique for paying attention; sunlight is not a kind of shade (nor even its opposite): atheism simply means that one has no religious beliefs.

Even to call it "non-belief" is perhaps misleading. After all, when you're feeling comfortable you don't call it "non-pain".

Many believers literally cannot imagine that atheism is possible. But millions of us enjoy it – all day, every day.

Takoma Park, Maryland, US

For the record

● In the item on circumcision "To snip or not to snip" (25 November 2006, p 9), we cited the incidence of penile cancer as being 1 per 100,000 US males, but omitted to mention this was per year.

● Our email address letters@newscientist.com has been working, at best, sporadically – sorry. Try NS.letters@rbi.co.uk instead.

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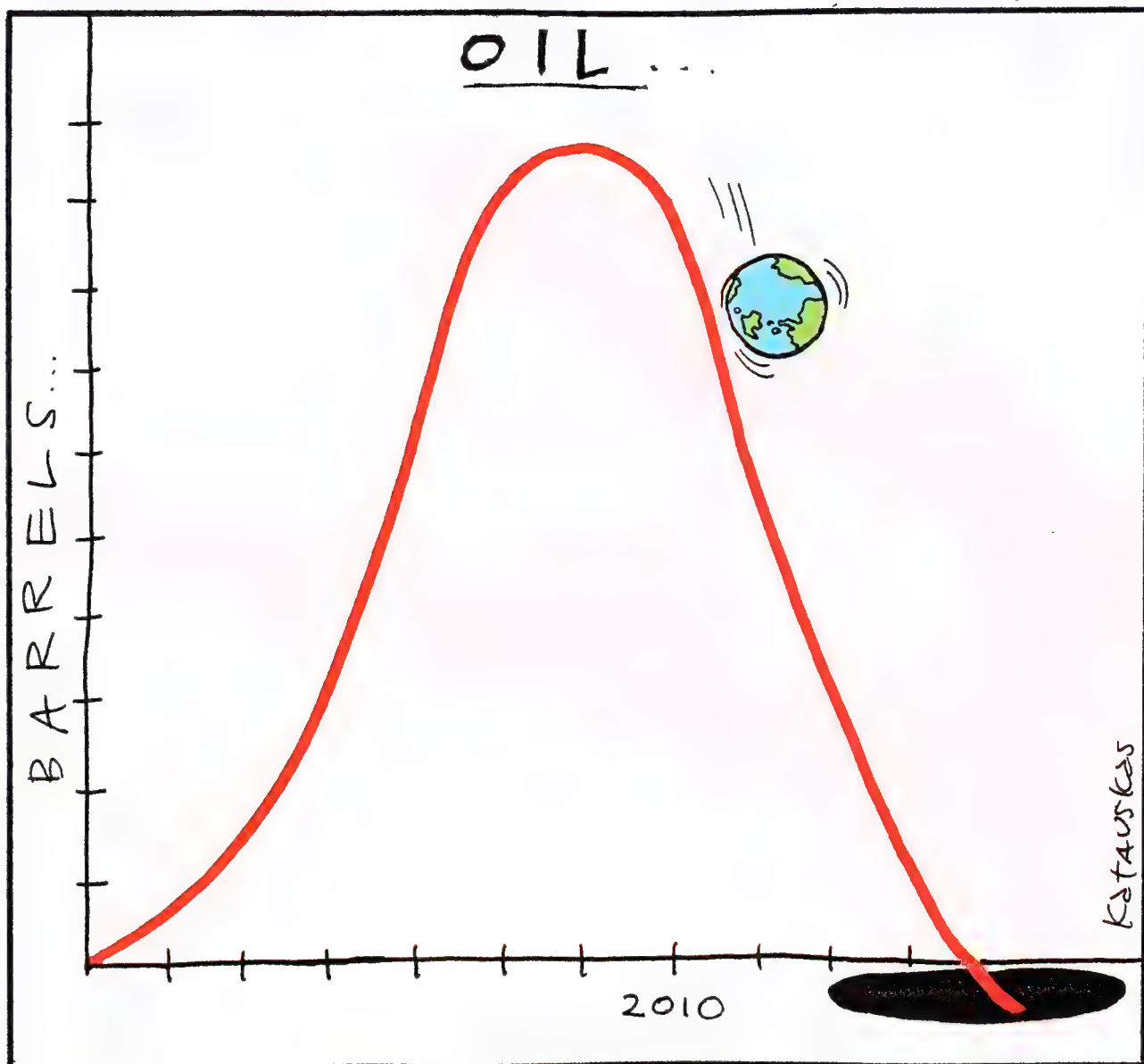


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Technology

ROBOT LEARNS TO PLAY DIRTY

Beating people at Scrabble is already no contest for computer programs, which can easily memorise entire dictionaries. Now a Scrabble-playing program has gone one better by playing dirty.

Developed by Eyal Amir and Mark Richards at the University of Illinois, Urbana-Champaign, the program is able to predict which letter tiles other players hold, and use this information to choose moves which block a high-scoring word that an opponent might otherwise have played. This aggressive gaming style gives it the edge over previous Scrabble programs, which focus solely on maximising their own scores.

To predict what tiles other players hold, Amir and Richards's program begins by eliminating those tiles that have already been played. It then

narrows down the possibilities by assuming that the tiles left on an opponent's rack after they make a move do not include any letters that could have been used to form higher-scoring words than the word the opponent actually played. Adding in this "opponent modelling" greatly improved the program's game, allowing it to beat Quackle, one of the best conventional Scrabble programs, by five points on average.

Amir says his program can do more than simply beat its rivals. Because its play is more human-like than other Scrabble-bots, it could serve as a useful tool for training people to play against other people. He presented the bot at a conference on artificial intelligence in Hyderabad, India this week.



High-scoring words aren't everything

Airbus eyes iris scanner for pilots

AIRBUS has filed a patent application on an anti-terror technology that it once ruled out as a non-starter.






In the nervous days after 9/11, *New Scientist* asked the company if it would consider applying biometric devices, such as iris or fingerprint scanners, to the aircraft controls to ensure only the pilots could use them (22 September 2001, p 10). Airbus said such technology would be too difficult to deploy and could distract the crew.

But in US patent filing 2006/0245629, Airbus is clearly reconsidering cockpit biometrics, with the addition of wide-angle CCTV so the cabin crew or control tower can check that pilots are not being forced to scan their details on behalf of a hijacker. Airbus declined to provide further details for security reasons.



CAN'T CONNECT

The top five headaches when automating electrical and electronic systems in US homes

-  Network installation is confusing
-  Signal quality varies, wrecking communication
-  Too many incompatible systems
-  No standards for heating, lighting connections
-  Version clashes between wireless networks

SOURCE: I-MARKETMOUSE

Both sides backed in hi-def DVD war

HIGH-DEFINITION DVDs and disc players unveiled at the Consumer Electronics Show in Las Vegas, Nevada, this week could allow consumers to avoid having to choose one of two rival formats – but at a price.

South Korean firm LG will offer a player that can read both Blu-ray discs, which store data in a single layer, and HD DVD discs, made by

bonding two thinner discs back to back. As different lenses are needed to focus the laser that reads the discs, the dual-format player will cost more to make than single-format Blu-ray or HD DVD players. It will sell for \$1200.

Meanwhile Warner Bros plans to support both formats by making discs that will work in either type of player. The US studio's new Total Hi-Def discs will have a Blu-ray movie on one side and the same film in HD DVD format on the other.

GIZMO

Unfazed by the carbon emissions caused by power-hungry gadgets? Then a dream device for you is launching this summer. The world's largest LCD flat-screen TV was previewed by Sharp Electronics at this week's Consumer Electronics Show in Las Vegas, Nevada. The 108-inch (274-centimetre) TV beats Panasonic's previous record holder by 13 centimetres, and its picture is said to be as clear as any plasma model.

If you get frustrated when characters in TV dramas make bad decisions, help is on the way. ShapeShiftedTV, developed by the European NM2 consortium, lets viewers manipulate the storyline via SMS. The technology analyses multiple messages for keywords – "dump him", for instance – and then selects an appropriate follow-up scene from a range of alternatives. It has been used in a Finnish romantic comedy.

SOURCE: ELECTRONIC ENGINEERING TIMES

"Maybe dog owners have some kind of useful personality trait"

Laszlo Bock, Vice President of People Operations at Google, on one of the factors relating to job hopefuls' attitudes, behaviour and personality that the company is feeding into a series of mathematical formulae to predict whether they fit into the organisation's culture (*The Observer*, London, 7 January)

Arctic robots to get first taste of 'alien' life

What will the exotic inhabitants of the Arctic's hydrothermal vents look like? We'll soon find out

MICHAEL REILLY

AT THE bottom of the Arctic Ocean is an ecosystem that has been isolated for the past 65 million years, since geological activity separated it from the Mid-Atlantic Ridge. Like the teeming ecosystems that line volcanic ridges in the Atlantic and Pacific, its denizens, which are likely to be unique, subsist on heat and nutrients coughed up from the Earth's interior by hydrothermal vents.

Apart from one mapping mission and an expedition that returned a few snapshots and bits of rock in 2001, for all we know about this intriguing marine life, it might as well exist on Mars. "With the possible exception of Lake Vostok in Antarctica, this is the closest you can come on this planet to an alien life form," says David Akin of the University of Maryland, College Park, who plans to plumb these unknown depths with robots later this year.

The lack of knowledge is partly due to difficulties inherent in exploring the ocean under thick ice-sheets that even ice-breaking ships have problems getting through, but it also stems from the fact that until recently, it was far from clear that there was life there anyway. That changed in 2001 when an underwater Arctic mission discovered eight

hydrothermal vents along the Gakkel Ridge, which lies between Greenland and Siberia. These could well harbour exotic life forms because of the heat and nutrients they provide. The submarine was able to map their locations to within 5 kilometres and since then scientists have been itching to return to these vents, some of which lie more than 5 kilometres below sea level.

Now that looks as if it will happen. In August 2007 two intrepid robots that Akin helped to design and build will venture into the Gakkel Ridge to bring back the first ever biological samples from under the Arctic ice.

Much like the Martian rovers Spirit and Opportunity, the two Autonomous Underwater Vehicles (AUVs), Puma and Jaguar, will explore unaided. Almost entirely cut off from the world above the ice, they will sniff out active hydrothermal vents, scan for life, sample what they find and return to the surface, using cutting-edge sensing and navigational technologies.

The journey will be fraught with difficulty, not least because communicating with underwater vehicles is even harder than talking to distant spaceships.

"If we were going to be in the open ocean, my state of stress and panic would be lower"



Since electromagnetic waves barely propagate through water, the best way to send data is via acoustic signals, but these weaken rapidly with distance. "Within 5 kilometres, you might have some idea of where it is," says Ken Collins of the National Oceanography Centre in Southampton, UK. "After that, it's easier to talk to a probe on Mars."

This won't hamper AUVs operating in open water, because they can carry out pre-programmed missions while maintaining only minimal contact with the mother ship, and surface at a predetermined location. But pulling off this rendezvous with an ice sheet in the way is a different matter.

The bots will have a relatively easy start to their mission – being simply lowered through a hole punched in the ice by an ice-breaking ship – but retrieving them will be no mean feat.

Although the bots record the location of the initial hole and are programmed to return to that spot, the hole can freeze over or the ice sheet can drift by several kilometres.

"There's always the potential that you'll drop the thing in a hole in the ice, wave goodbye and it'll never come back," Akin frets.

"If we were going to be in the open ocean, my state of stress and panic would be way lower," adds Hanumant Singh of the Woods Hole Oceanographic Institute in Massachusetts, leader of the team that designed and built the two AUVs.

Indeed, in 2005, Collins's team, lost a £5.5-million AUV called Autosub beneath the Fimbulisen ice shelf in Antarctica. They believe it smashed into the ice while trying to get back to the surface. Now the sub remains stuck until global warming sees fit to extricate it.

To avoid this occurring again, Singh's team has equipped Puma and Jaguar with a navigation system that can communicate



Truly unique life forms lie far beneath

with the mother ship via sonar as the bots near their original hole, rather than relying purely on the coordinates recorded when they first descended through the ice.

"We can talk to the vehicle and say 'Okay, the hole has moved, here's the new location. Go here,'" says Singh. But there is still nothing to be done about the ice when a bot has to surface due to an emergency, such as a loss of power or bearings. In these cases the bot is simply programmed to surface as quickly as possible, with the team hoping for the best.

While retrieving the submersibles may be the most hair-raising part of any mission beneath the ice, Puma and Jaguar's real task lies in finding Gakkel's hidden life forms. The two car-sized bots will work in tandem (see Denizens of the Gakkel Ridge). Puma will set off first to carry out the initial rough location work, reducing the likelihood of losing Jaguar, which is more expensive and delicate as it is equipped with the robotic arm, dubbed SAMURAI. "You look

at what happened to Autosub and the odds are fairly high that that could happen to us. They are not sacrificial but, well, that's why we built two."

Puma will sniff out active hydrothermal vents using specialised chemical and temperature sensors. The vents constantly spew into the ocean a plume of chemicals that over time cool and change in chemical composition. By constantly monitoring the concentrations of dissolved iron and gases, as well as the temperature of the water, Puma can calculate how old the plume is and use this to zero in on the vent.

When it has narrowed the source of the plume to within a few tens of metres, it records its location and returns to the mother ship. There, researchers load these co-ordinates onto Jaguar and dispatch it for more accurate mapping and imaging.

Jaguar has a pair of cameras to see in three dimensions, and shape and colour-recognition software for homing in on objects that are likely to be alive. When it finds something it would like to sample, it settles on the ocean floor and directs its robotic arm to scoop it up.

The robots are designed to perform the entire mission without a human looking over their shoulders. However, like nervous parents their creators will initially watch them closely, sending them on short, incremental missions. "We want to push the envelope every time we go out, but won't bet the house on them," says Singh. "We'll say 'Do your best,' and if they perform well the first few times, we can let them make more decisions on the fly."

This is especially true for the biological samples. Although Jaguar is supposedly capable of identifying and retrieving samples in one trip, Akin says that after its computer completes visual scans of the vent field for possible life, Jaguar will return to the ship and biologists will decide what should be sampled.

"We can look at an object and say, 'This is probably a tube worm or a shrimp,' and designate it as a target," he says. Then Jaguar will be sent back down to search out specific targets.

One snag is that the team may be no better than the robots at spotting life because the form it takes is likely to be unique. "Gakkel Ridge has been separated from the Mid-Atlantic Ridge for tens of millions of years. No one knows what to expect there," says Richard Camilli,

a chemist at Woods Hole.

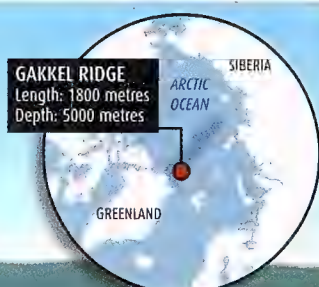
But if the mission is successful, it will be the first time an autonomous seagoing robot has managed to grab a biological sample. "This represents a whole new level of autonomy," says Akin, who works on similar devices for space. "They don't even give this level of autonomy to astronauts."

The mission could even inspire an expedition to the frozen oceans of Jupiter's moon Europa in search of truly alien life. ●

DENIZENS OF THE GAKKEL RIDGE

Puma goes first, narrows location of hydrothermal vent to within a few tens of metres. Jaguar is then dispatched, carrying the SAMURAI optical navigation system and robotic arm

When jaguar sees something that looks like life - it will set down on the ocean floor and direct the robotic arm to a target



Setback for safe storage of nuclear waste

A MATERIAL that promised to lock up nuclear waste for hundreds of thousands of years may not be up to the job.

At present high-level waste is "vitrified" by combining it with liquid borosilicate glass and solidifying the mixture. This makes the waste safer as it delays leakage of the radioactive material. The glass is not ideal, though, because geological activity can break it up, so researchers are on the lookout for more robust "immobilisation" materials.

Minerals such as zircon ($ZrSiO_4$) are believed to have kept naturally occurring radioactive uranium and thorium locked in the Earth's crust for up to 4.4 billion years, surviving earthquakes and volcanic eruptions. As a result researchers have argued that zircon, or similar synthetic ceramics, could trap nuclear waste within their crystalline structures for at least 241,000 years, the time

plutonium-239 takes to become relatively safe.

Now a study shows that this is unlikely. It turns out that alpha particles released as plutonium decays knock the atoms in zircon out of position faster than originally predicted, impairing the material's ability to immobilise waste (*Nature*, vol 445, p 190).

Ian Farnan of the University of Cambridge and colleagues at the Pacific Northwest National Laboratory in Richland, Washington, added plutonium to zircon and used nuclear magnetic resonance spectroscopy to distinguish between crystalline zircon and its leaky, damaged form.

The researchers found five times as many damaged zircon atoms as estimated by computer simulations. They conclude that radioactive plutonium trapped in zircon would start leaching out after just 210 years and lose its crystal structure entirely after 1400 years.

The result could dash hopes for ceramics similar to zircon under consideration in Australia, Russia and the US. Farnan believes, however, that it is still possible to develop synthetic ceramics that don't lose their crystalline structure as quickly as zircon. "We have demonstrated a method that will allow us to be more confident about the storage of waste in the future," he says. Rob Edwards ●

How to leak a secret and not get caught

LEAKING a sensitive government document can mean risking a jail sentence – but not for much longer if an online service called WikiLeaks goes ahead. WikiLeaks is designed to allow anyone to post documents on the web without fear of being traced.

The creators of the site are thought to include political activists and open-source software engineers, though they are keeping their identities secret. Their goal is to ensure that whistle-blowers and journalists are not thrown into jail for emailing sensitive documents. That was the fate of Chinese journalist Shi Tao, who was sentenced to a 10-year term in 2005 after publicising an email from Chinese officials about the anniversary of the Tiananmen Square massacre.

According to the group's website www.wikileaks.org, its primary targets include China, Russia, and oppressive regimes in Eurasia, the Middle East and sub-Saharan Africa. It is not limited to these countries, however, and people anywhere will be able to use the site to reveal unethical behaviour by governments and corporations.

Normally an email or a document posted to a website can be traced back to its source because each data packet carries the IP address of the last server that it passed through. To prevent this, WikiLeaks will exploit an anonymising protocol known as The Onion Router (Tor), which routes data through a network of servers that use cryptography to hide the path that the packets took. Bruce Schneier,

a cryptographer based in Silicon Valley, California, explains it like this. "Imagine a large room jammed full of people in which many of them are passing around envelopes. How would you know where any of them started?"

Julien Pain, a campaigner with Reporters Without Borders in Paris, France, sees Tor as a valuable step towards guaranteeing anonymity.

"Enabling cyber-dissidents to leak information is a crucial issue we now face in many countries," he says. There are however, fears that whistle-blowers might still be at risk. "I would not trust my life or even my liberty to Tor," says Ben Laurie, a London-based computer security expert.

In the past, determined cryptographers have breached Tor's security, and though each breach has led to improvements to Tor there is always a risk others will be discovered.

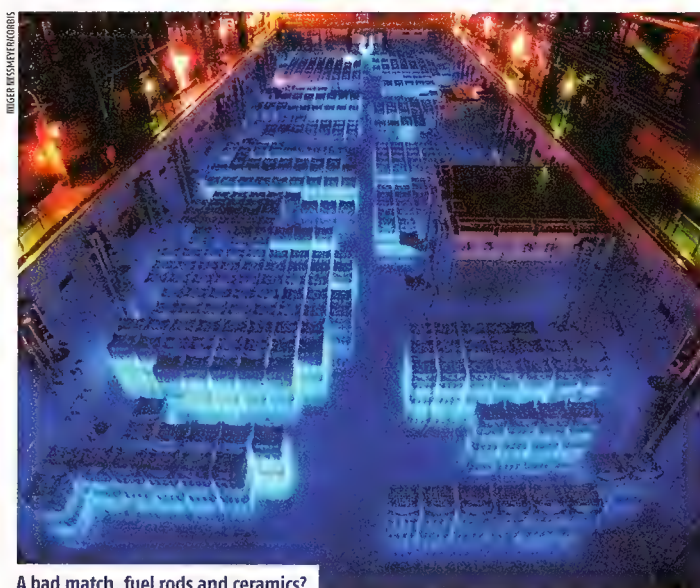
The WikiLeaks team do not plan to control what is disclosed on the site, raising fears that the anonymity it offers could be misused. "The initiative could drown in fabricated documents,

"Targets include China, Russia and oppressive regimes in the Middle East"

pornographic records or become hijacked to serve vendettas," warns Steven Aftergood of the Federation of American Scientists in Washington DC.

The safeguard against this, according to the WikiLeaks team, is that false postings will be sniffed out by users, who will be free to comment on what is posted. This is what happens with Wikipedia, which although unconnected to WikiLeaks is based on the same open-source software. "WikiLeaks will provide a forum for the entire global community to examine any document relentlessly for credibility," the site claims.

WikiLeaks is raising funds and testing its software. It hopes to launch in February. Paul Marks ●



A bad match, fuel rods and ceramics?



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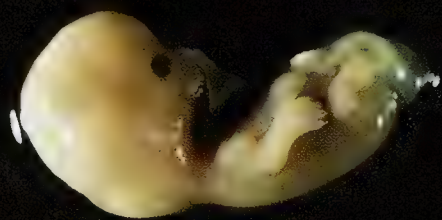


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Evolution isn't supposed to run backwards,
but when it does it can sometimes
represent the future of a species – even us.

By Michael Le Page

The ancestor within





FROM October to April every year, fishermen in Taiji in Japan herd schools of dolphins and porpoises into shallow bays and slaughter them for food. Each year they kill around 20,000 animals. That would have been the fate of one particular dolphin, a bottlenose that scientists now call AO-4, had fishermen not spotted something rather unusual about it.

What saved the dolphin's life was an extra pair of flippers. In addition to the usual front pair, it had a smaller pair at the back (see Photos, page 30). Experts were quick to point out that these were similar to the hind flippers seen in early dolphin fossils. "It looks like the dolphins' ancestors from 40 million years ago," says Johannes Thewissen, an expert on cetacean evolution at Northeastern Ohio Universities College of Medicine in Rootstown.

The press lapped it up, reporting the dolphin as an "evolutionary throwback". The idea made for a great story, but is there any credibility in it?

The description of any animal as an "evolutionary throwback" is controversial. For the better part of a century most biologists have been reluctant to use those words, mindful of a principle of evolution that says "evolution cannot run backwards". But as more and more examples come to light and modern genetics enters the scene, that principle is having to be rewritten. Not only are evolutionary throwbacks possible, they sometimes play an important role in the forward march of evolution.

The technical term for an evolutionary throwback is an atavism, from the Latin *atavus*, meaning forefather. The word has ugly connotations thanks largely to Cesare Lombroso, a 19th-century Italian medic who argued that criminals were born not made and could be identified by physical features such as low foreheads and long arms that were throwbacks to a primitive, sub-human state.

While Lombroso was busy measuring criminals, a Belgian palaeontologist called Louis Dollo was studying the fossil record and coming to the opposite conclusion. In 1890 he proposed that evolution was irreversible: that "an organism is unable to return, even partially, to a previous stage already realised in the ranks of its ancestors". Early 20th-century biologists came to a similar conclusion, though they couched it in terms of probability – there is no reason why evolution cannot run backwards, it is just vanishingly unlikely. And so the idea of irreversibility in evolution stuck and came to be known as "Dollo's Law".

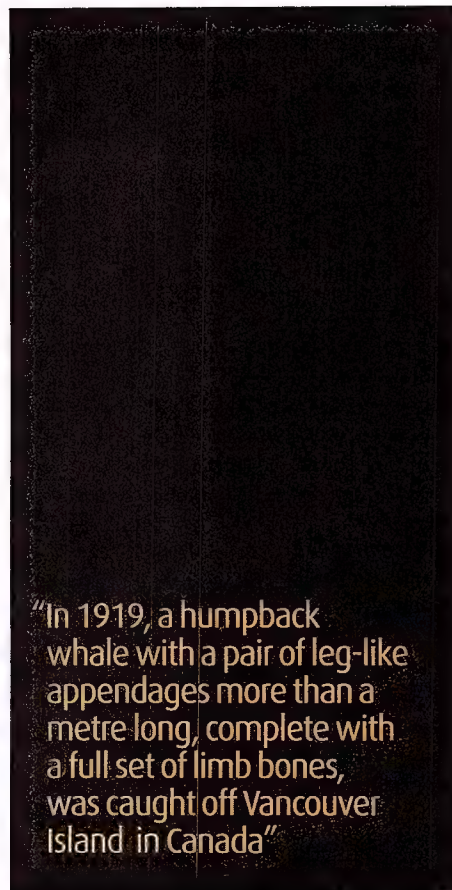
If Dollo's Law is right, atavisms should occur only very rarely, if at all. Yet almost since the idea took root exceptions have been cropping up. In 1919, for example,

a humpback whale with a pair of leg-like appendages over a metre long, complete with a full set of limb bones, was caught off Vancouver Island in Canada. Explorer Roy Chapman Andrews argued at the time that the whale must be a throwback to a land-living ancestor. "I can see no other explanation," he wrote in 1921.

Since then so many other examples have been discovered that it no longer makes sense to say that evolution is as good as irreversible. And this poses a puzzle: how can characteristics that disappeared millions of years ago suddenly reappear?

In 1994, Rudolf Raff and colleagues at Indiana University in Bloomington decided to use genetics to put a number on the probability of evolution going into reverse. They reasoned that while some evolutionary changes involve the loss of genes and are therefore irreversible, others may be the result of genes being switched off. If these "silent genes" are somehow switched back on, they argued, long-lost traits could reappear.

Raff's team went on to calculate the likelihood of it happening. Silent genes accumulate random mutations, they reasoned, eventually rendering them useless. So how long can a gene survive in a species if it is no longer used? The team calculated that there is a good chance of silent genes surviving for up to 6 million years in at least a



"In 1919, a humpback whale with a pair of leg-like appendages more than a metre long, complete with a full set of limb bones, was caught off Vancouver Island in Canada"

few individuals in a population, and that some might survive as long as 10 million years. In other words, throwbacks are possible, but only to the relatively recent evolutionary past.

As a possible example, the team pointed to the mole salamanders of Mexico and California. Like most amphibians these begin life in a juvenile "tadpole" state then metamorphose into the adult form – except for one species, the axolotl, which famously lives its entire life as a juvenile. The simplest explanation for this is that the axolotl lineage alone lost the ability to metamorphose, while others retained it. From a detailed analysis of the salamanders' family tree, however, it is clear that the other lineages evolved from an ancestor that itself had lost the ability to metamorphose. In other words, metamorphosis in mole salamanders is an atavism. In fact, metamorphosis appears to have flickered on and off across the group for 10 million years, with some species losing the ability only for their descendants to regain it.

The salamander example fits with Raff's 10-million-year time frame. More recently, however, examples have been reported that break the time limit, suggesting that maybe silent genes are not the whole story.

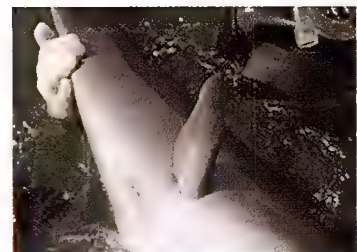
In a paper published last year, biologist Gunter Wagner of Yale University reported some work on the evolutionary history of a ►

group of South American lizards called *Bachia*. Many of these have minuscule limbs; some look more like snakes than lizards and a few have completely lost the toes on their hind limbs. Other species, however, sport up to four toes on their hind legs.

The simplest explanation is that the toed lineages never lost their toes, but Wagner begs to differ. According to his analysis of the *Bachia* family tree, the toed species re-evolved toes from toeless ancestors. What is more, digit loss and gain has occurred more than once over tens of millions of years. "In this particular case, we have disproved Dollo's Law," Wagner says (*Evolution*, vol 60, p 1896). Another recent paper suggests that stick insects lost their wings 300 million years ago, only for some lineages to re-evolve them at various later dates (*Nature*, vol 421, p 264).

So what's going on? One possibility is that these traits simply re-evolve from scratch in much the same way that similar structures can independently arise in unrelated species, such as the dorsal fins of sharks and killer whales. Another more intriguing possibility is that the genetic information needed to make toes or wings somehow survived for tens or perhaps hundreds of millions of years in the lizards and stick insects and was reactivated. These atavistic traits provided an advantage and spread through the

This dolphin, caught off Japan last year, escaped certain death thanks to its unusual hind flippers



Human throwbacks – or not?

LARGE CANINES

Some of us have particularly large canines reminiscent of the fangs of chimpanzees and gorillas. Darwin himself viewed these as a throwback: "He who rejects with scorn the belief that the shape of his canines, and their occasional great development in other men, are due to our early forefathers having been provided with these formidable weapons, will probably reveal, by sneering, the line of his own descent."

Fossil teeth from the earliest hominoids suggest that the canines began shrinking as soon as we diverged from our common ancestor with chimps. One theory is that this was a result of a different social structure where males no longer fought for access to females.

Atavism? Possibly

EXTRA NIPPLES OR BREASTS

Most mammals have multiple pairs of nipples; like most primates we have only one. Reversions are common: around 1 in 20 people has at least one extra nipple and some have as many as six. These "supernumerary" nipples range from a patch of darker, areolar skin to a complete nipple or even an entire breast that can produce milk.

In humans, extra nipples usually occur along the

milk lines, two thickened areas stretching from the armpits to the groin that appear in the embryo in the fourth week or so. In other mammals this tissue gives rise to up to five pairs of nipples.

Extra nipples sometimes form off the milk lines, even on the face or legs. A 19th-century medical book describes a woman who could breastfeed from an extra breast on her leg. Such cases may be due to the failure of cells to migrate to the right place during development.

Extra nipples are often seen in other primates too. In one group of macaques in Taiwan, up to a third of females have extra nipples.

Atavism? When on the milk lines, yes

HAND-WALKING

"'Backward' evolution spawns ape-like people," declared the headline back in February 2006. The story was about the discovery of five Turkish siblings aged 14 to 32 who walked on all fours. Their discoverer claimed that their gait resembled that of apes and suggested it was an evolutionary throwback to the days when our ancestors walked on all fours (*International Journal of Neuroscience*, vol 116, p 361)

Some researchers suspected a hoax. But as a BBC documentary recently shown in the US revealed,

"It's clear that atavisms are far more common than biologists once believed. They are lurking within all our genomes, ready to emerge if anything goes awry during development"

Are extra fingers a throwback to the past when our amphibian ancestors had eight?



AP/WIDEWORLD

Mole salamanders like the axolotl (left) may be the best example we have of evolution in reverse



STEPHEN GARDINER/INPA

the siblings simply had brain damage affecting their balance. As infants they learned to "bear-walk", as many children do. But they never made the transition to upright walking – at least not until a psychologist who took part in the TV programme arranged some basic physiotherapy.

Atavism? No

UNDERDEVELOPED THUMB

Some people are born with short thumbs lacking some of the usual muscles. A few also have long, slender fingers, rather like the hands of chimps. In some cases the thumb joint is not as flexible as normal, meaning people lack a fully opposable thumb.

Atavism? Unclear

LACK OF SWEAT GLANDS

Some people lack sweat glands, and in this they superficially resemble apes. But most cases seem to involve mutations that block sweat gland formation altogether, whereas in apes it's the distribution that's different, with the sweat glands mostly limited to the palms and soles of feet.

Atavism? Probably not

POLYDACTYLY

Extra fingers or toes are one of the most common congenital defects and occur in many animals too, including dogs and cats.

Work by John Fallon of the University of Wisconsin and his team has shown that the two genes that determine digit identity – which is the thumb, which the index finger, and so on – also seem to limit the number of digits to five. If these genes are knocked out in mice, they end up with six to eleven identical digits, rather like the very earliest amphibians, which had eight identical digits. More minor disruptions to these genes may produce some of the forms of polydactyly seen in people.

Atavism? Probably

SYNDACTYLY

Webbed fingers or toes are a common birth defect. In most cases the middle fingers or middle toes are joined together. This can happen because our hands and feet start off as flat structures. Gradients set up across them establish where the fingers or toes should be and the tissue between the fingers or toes later self-destructs. Webbed hands and feet are probably a result of this self-destruct program being disrupted.

Syndactyly could therefore be seen simply as a developmental defect, but it would not happen if our fingers and toes sprouted from individual "buds" as the limbs do, rather than by dividing a flat structure into five. And the reason the hands and feet form the way they do is because they evolved from the fins of the ancient lobe-finned fishes.

Atavism? Almost certainly

population, effectively reversing evolution.

But if silent genes degrade within 6 to 10 million years, how can long-lost traits be reactivated over longer timescales? The answer may lie in the womb.

Early embryos of many species develop ancestral features. Snake embryos, for example, sprout hind limb buds, as do whale and dolphin embryos. Human embryos have a tail bud. Later in development these features disappear thanks to developmental programs that say "lose the leg" or "lose the tail".

Ancestral mystery

If this "lose it" program goes wrong, however, perhaps through a mutation, the ancestral feature may not disappear. "If this mechanism is released, you get what can legitimately be called an atavism," says Wagner. Perhaps that is what happened to the Japanese dolphin; it could also explain why adult whales and dolphins sometimes have bony lumps where their hind limb buds were, and why snakes with hind limbs are caught from time to time.

But why retain ancestral structures and start building them in early development only to get rid of them later? In some cases, primitive features still play a role in development. For example, vertebrate embryos develop a notochord, a cartilaginous spine ▶

BRANCHIAL CLEFT CYST

In the fourth week of development, vertebrate embryos develop five ridges in the neck region. In fish, these ridges go on to form the gills, or branchia. In humans, they form various structures in the head or neck. The clefts between the ridges normally disappear but sometimes a fluid-filled sac called a branchial cleft cyst remains.

Atavism? Perhaps best described as an atavistic vestige

TWINNING

It's been suggested that having twins or triplets is a throwback to the large litters of our early mammalian ancestors. Some women inherit a tendency to have non-identical twins, which form when two eggs are released and fertilised instead of one.

Atavism? Unclear

HICCUPS

Hiccups have baffled people for centuries. One recent proposal is that hiccupping is a primitive reflex inherited from our land-conquering ancestors. These primitive air breathers had both gills and lungs, like the lungfish. The pattern of muscle movements in hiccups resemble those seen when such animals close their glottis to stop water getting into the lungs and contract the mouth cavity to pump water over the gills (*New Scientist*, 8 February 2003, p 16).

Atavism? Perhaps

similar to that of early vertebrates, which then acts as a template for the backbone proper. "It has a vital embryonic function even though it has no adult function," says Brian Hall, a biologist at Dalhousie University in Canada who has studied atavisms.

Other transient embryonic features such as the hind limb buds of whales are harder to explain. One possibility is that they play an as-yet unknown role in development. Another possibility, says developmental biologist Jonathan Slack of the University of Bath, UK, is that they are there because there has never been any evolutionary pressure to eliminate them. "The tail bud is there because it was there, not because there is any particular function for it," Slack says.

Hens' teeth and hairy faces

This, though, raises another question: why haven't the genes that initiate limb or tail development fallen into disrepair like any other silent gene? The answer may be that they are not really silent.

Even when a structure is no longer needed, the genes involved can be conserved as long as they are also needed to make other parts of the body. As Hall points out, there is no such thing as a gene for a leg or a tail. Instead there are genes that form the underlying patterns of numerous structures and many of the same genes are involved in laying down quite different body parts. In birds, bats and insects, for example, wings are a variation on the theme of legs. Hair, teeth, feathers and scales are also all variations on a theme – which is why some disorders cause hair to sprout from people's gums.

What that means is that the genes needed to make a long-lost trait are not always "silent" and can survive for much longer than the 10 million year limit estimated by Raff. And if the genes are still there, it is plausible that ancient developmental programs can spring back to life.

There are some examples. Birds lost their teeth around 70 million years ago, yet in a famous experiment in 1980, Edward Kollar of the University of Connecticut managed to coax chicken cells to grow into rudimentary teeth by grafting them onto mouse jaw tissue (*Science*, vol 207, p 993). Kollar interpreted this to mean that he had somehow reawakened a dormant genetic program, but the results were controversial: critics like Raff suggested that the so-called "hens' teeth" were just an artefact. Last year, though, the critics were silenced when John Fallon at the University of Wisconsin described a mutation that triggers the development of crocodile-like teeth in chicken embryos (*Current Biology*, vol 16, p 371). "I would be cautious," says Fallon,



CHINA FOTO PRESS/GETTY IMAGES

The hind limb buds of snakes usually disappear in the egg, but very occasionally they persist



CHINA FOTO PRESS/GETTY IMAGES

who talks of "tooth-like structures" rather than teeth. "But when push comes to shove, I'd call it an atavism."

Even if the hens' teeth genes have survived because they are used in other parts of the body, this doesn't explain everything. It is still surprising that they can be switched back on in the right place and in the right order to recreate a long-lost feature. "I don't know how it's possible," Fallon admits.

So if atavisms are genuine throwbacks and appear in all sorts of animals, what about us? It's roughly 6 million years since our lineage split from chimpanzees, and we have evolved rapidly in this time. Our fingers and palms have become shorter and our thumbs longer, stronger and more flexible. We've lost our fur and gained many more sweat glands. We have become bipedal and, of course, acquired language and unique cognitive skills.

There are plenty of cases in the medical literature in which these body parts appear to have reverted to the ancestral state, from large canines to chimp-like toes. Some behaviours, too, appear to be throwbacks to an ancestral state (see "Human throwbacks – or not?", page 30). But are any of these really atavisms? Until genetic analysis reveals whether these conditions are genuine reversions, rather than developmental disorders that happen to resemble ape features or behaviours, it is hard

"Birds lost their teeth some 70 million years ago, yet in a famous experiment biologists managed to coax chicken cells to grow into rudimentary teeth by grafting them onto mouse jaw tissue"

Stick insects lost their wings in the deep evolutionary past only to re-evolve them later



TOMMY CARROLL/SCIENCE PHOTO LIBRARY



Webbed toes are one of the few birth defects that are almost certainly atavisms

"There are more than 100 medical reports of human babies born with tails. Some are no more than fatty appendages, but others have vertebrae and can even move"

to say for sure. But there are some cases where the evidence points to a firm conclusion.

One condition often cited as an atavism, for example, is "werewolf syndrome", or hypertrichosis, a group of very rare conditions in which the entire face and other parts of the body are covered in thick hair. Take a look at a chimp or gorilla, and you'll see they have less facial hair than many ecologists. There is even one report of a gibbon – another ape with a hairless face – with hypertrichosis. So if these conditions are an atavism, it's certainly not a reversion to our recent ape ancestors.

Driving evolution forward

Another possibility is that some behavioural syndromes are atavisms. In 2002 researchers at Leiden University in the Netherlands suggested that cataplexy, a condition in which strong emotions cause the muscles to suddenly go limp, is a throwback to an ancestral "fright paralysis" response similar to rabbits freezing in headlights. Similarly, our habit of moving our mouths when using our hands for tricky tasks such as sewing could reflect the behaviour of our simian ancestors, who usually use their mouths and hands together. Until we start to understand the genetic basis of instincts and behaviours, though, ideas like this remain unproven.

There is one bizarre condition, however, that is almost certainly a human atavism. There are more than 100 reports in the literature of babies born with tails. Some are no more than fatty appendages, but others consist of extra vertebrae, ligaments and muscle, and can even move – though as most are removed soon after birth, it's not clear whether this movement is voluntary or not.

"This is quite clearly an atavism," says Bernhard Herrmann of the Max Planck Institute for Molecular Genetics in Berlin, Germany, who studies the development of the vertebral column. "The ability to make tails is a feature of all vertebrates."

As the embryo develops and elongates, a series of segments is laid down, he says. The first ones turn into the torso, while later ones become the tail, but exactly the same initial process – and the same set of genes – is involved. In humans the process stops early. But if something disrupts the "stop" signal, the elongation process may continue. "There is an inherent timing mechanism in the embryo that causes the tail to stop growing at the appropriate time for each species," says Andrew Copp of the Institute of Child Health in London, who has helped identify some of the genes involved in tail formation.

Once formed, the embryonic tail in humans self-destructs via a process of

programmed cell death, and the vertebrae in the rudimentary tail visible in 5-week embryos fuse to form the coccyx. Human tails could result from excessive elongation, or the failure of the self-destruct mechanism, or maybe a bit of both – the mutations responsible have not been identified.


Whether human tails resemble those of our ape ancestors is unclear. Fossil teeth are all that have been found of most transitional species between monkeys and apes, so when and why our ancestors lost their tails remains a mystery.

Whichever human conditions turn out to be atavisms – and we won't know for sure until the genetics of each of them is unravelled – it's apparent that they are far more common than biologists once believed. They are lurking within all our genomes, ready to emerge if anything goes awry during development. And in some cases, far from being a backward step, they prove to be advantageous and can spread through a species, driving evolution forward by making it go backwards. If humans ever have to return to the trees, our long-lost tails may be returning with us. ●

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Pharaohs from the

Remarkable discoveries on the fringes of the Sahara are forcing a rethink of the origins of ancient Egyptian civilisation. **Emma Young** reports

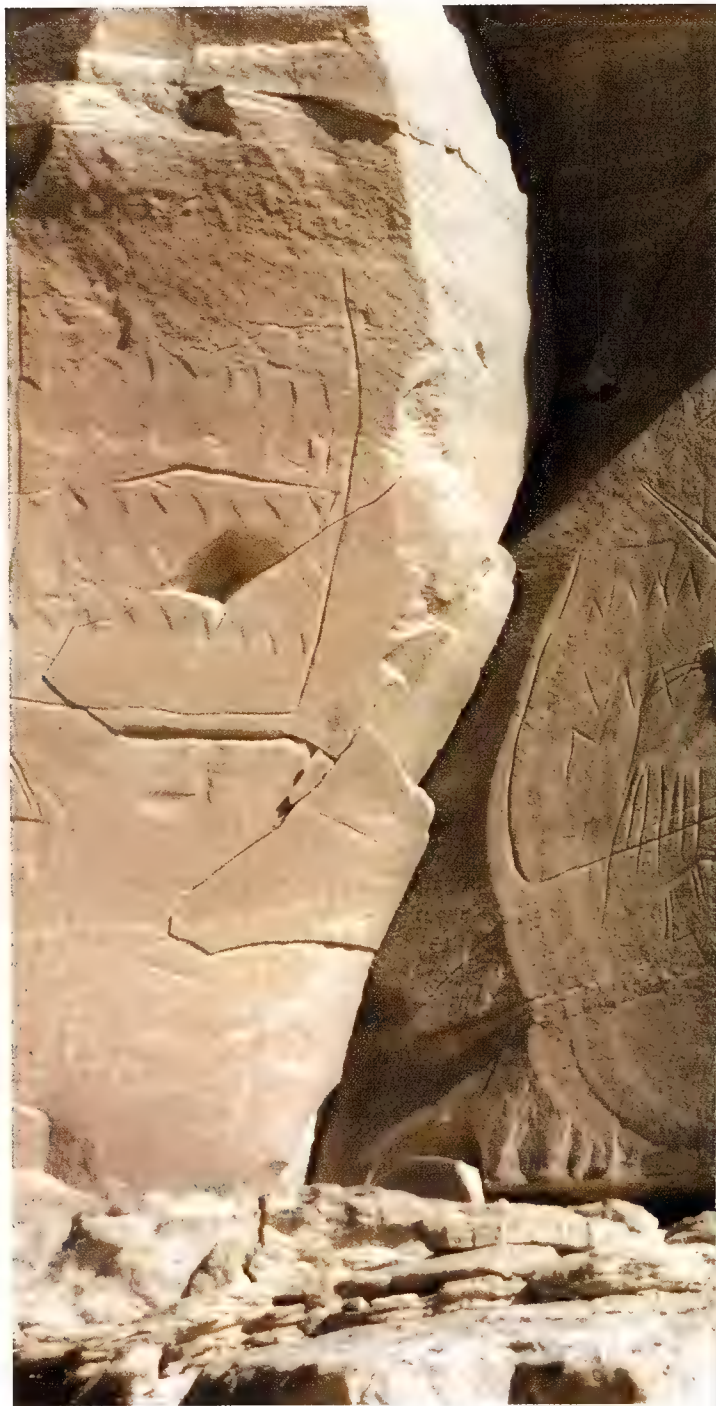
 IT WAS February 1999, and Carlo Bergmann had spent five days wandering through the desert with just his camels for company. His eyes were sore from the dust and from scanning the ground in front of him. Then he spotted them – two shards of pottery lying in the sand. They didn't look like much, but Bergmann knew at once what they meant. This one-time Ford motor company management trainee with no formal archaeological training had discovered an ancient trail that had eluded professional Egyptologists for almost a century. Here was a key piece in the puzzle surrounding the origins of the great civilisation of the pharaohs.

Eight years on, and amazing discoveries by Bergmann and a small band of researchers in the desert west of the river Nile are forcing Egyptologists to reconsider the origins of this ancient civilisation. In the 5th century BC, the historian Herodotus described pharaonic civilisation as a gift of the Nile. It now seems clear that the culture, technology, religion, economy and possibly even the hieroglyphic text of the pharaohs had roots not in the valley but in the desert far to the west.

The story of these discoveries has all the romance of an Indiana Jones script, complete with ancient maps, bitter rivalries and struggles for survival in the unforgiving desert. Bergmann, the amateur, was once the best of friends with a trio of prominent German academics who have been studying the region for decades. No longer. "If you look at the history of African exploration, sometimes those men would fight almost to the death," says one of the Germans, Stefan Kröpelin, a geologist with the Arid Climate, Adaptation and Cultural Innovation in Africa (ACACIA) unit at the University of Cologne. "It looks as if this tradition continues with Carlo."

Much of the background is uncontroversial. The first pharaonic dynasty was founded some time around 3100 BC by a ruler whose precise identity is unknown. With a capital at Memphis, near modern-day Cairo, the kingdom stretched southwards along the Nile valley all the way to Aswan. Egyptologists searching for clues to the origins of this

Carlo Bergmann followed what he believes is the world's oldest map to find 10 "wells" in the desert



stone age

A man with a beard and white shirt is sitting in a cave, surrounded by large rock formations. The cave is dimly lit, with light coming from the entrance, creating strong shadows. The man is looking directly at the camera. The rock walls of the cave are visible in the background, showing some texture and color variations. The overall mood is ancient and mysterious.

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RESEARCHERS PICTURES

civilisation have traditionally focused on the valley itself and on the desert to the east, between the Nile and the Red Sea, since hieroglyphic texts record many contacts with the Middle East via this route. Until the 1990s the only archaeological evidence of links to the now barren and hyper-arid region to the west was a mysterious pottery dump.

Discovered by Egyptologists in 1918, the site is known as Abu Ballas, or "father of the pots". Here, beside a hill about 200 kilometres south-west of the Dakhla oasis (see Map), early explorers found hundreds of complete and broken pots and amphorae, the oldest dating to the 6th dynasty, between around 2300 and 2100 BC. Since then, speculation about the site's significance has been rife. In 1939, the Hungarian explorer Lazlo Almasy, now famous as the central character in the book and 1996 film *The English Patient*, suggested that Abu Ballas might have formed a station on an ancient trans-Saharan trail leading west to Khufrah oasis in what is now Libya. Almasy searched for the trail, as did others after him, including Kröpelin's colleague, archaeologist Rudolph Kuper, all without success.

Enter Bergmann. In 1982 he had left Ford and had taken his PhD in marketing to the

American University in Cairo, where he was investigating a model for promoting marketing strategies in Egypt and elsewhere in the region. Then a trip to the camel market at Ed Debba in Sudan changed his life. "I got acquainted with the Sudanese camel drivers and I was inspired by them," Bergmann says. "I saw a harsh but self-determined life." He gave up his work, traded his briefcase for a camel, and became a camel driver.

Trans-Saharan highway

As Bergmann travelled the desert, he started to take an interest in archaeological remains, and in 1999 this led him to set out in search of the Abu Ballas trail. His starting point was Mery's rock, an outcrop carved with Middle Kingdom inscriptions that lies 35 kilometres from Dakhla oasis in the direction of Abu Ballas. Unlike Almasy and more recent desert explorers who travelled by car, Bergmann moved around on foot with his camels. "I thought this might give me a different perspective," he says. "I walked around the region, and about 1.86 kilometres west-south-west of Mery's rock I found the first 6th-dynasty pot shards. They were just

lying on the ground. This is like an open-air museum." That November, Bergmann took Kuper, Kröpelin and Egyptologist Klaus Kuhlmann of the German Archaeological Institute in Cairo to see his finds. Two weeks later, the team started excavating there, and unearthed what turned out to be the first of many stations along the Abu Ballas trail.

Meanwhile, Bergmann was patiently mapping the trail. For the rest of the year and into 2000, he followed small piles of rock laid out to mark the route; they would have been invisible to anyone speeding through in a car. The trail ran 350 kilometres south-west of Dakhla to the Gilf Kebir plateau – and then vanished. No one knows where it ultimately led. It might have reached Khufrah, as Almasy speculated, or Gebel Uweinat, another site with permanent water 200 kilometres to the south-west. From there, it would have been possible to penetrate deeper into the continent, perhaps even as far as modern-day Chad, Kuper says.

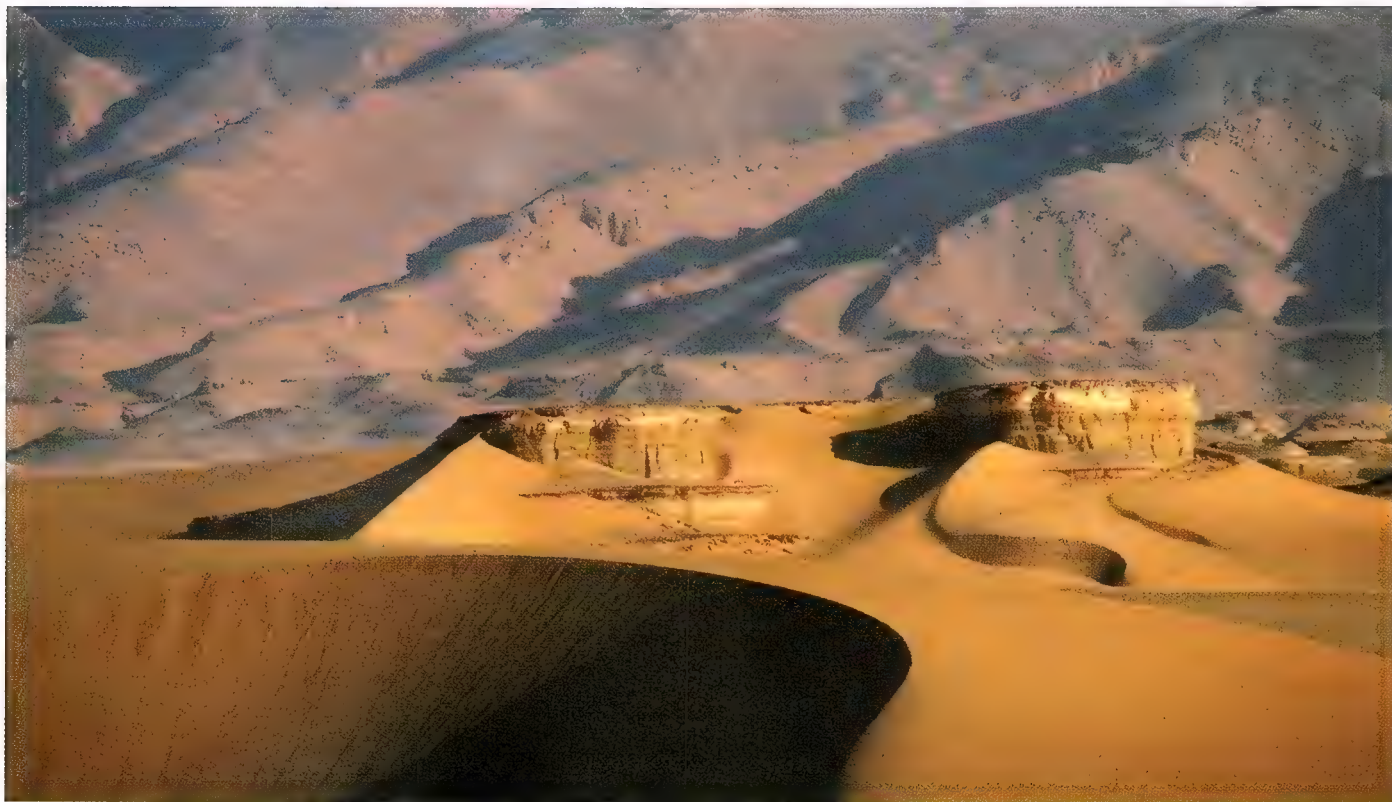
The German team has now excavated 27 stations along the route, some of which may have served as camps for travellers on the Abu Ballas trail. "We even have almost 5000-year-old donkey footprints still visible – it's incredible," says Kröpelin. All agree that the trail is hugely significant. "It's the first trans-Saharan road – and it shows there were pharaonic expeditions deep into the desert," Kröpelin says. Kuper thinks it might have been used for trade – perhaps to transport ivory, ebony or gold from Africa's interior. The oldest pottery found along the route is from around 2300 BC, but Bergmann believes the trail itself could be much older, dating back perhaps to the Neolithic a few thousand years earlier. Kröpelin agrees, arguing that the first pharaonic ventures along that route could not have been accomplished without knowledge from earlier times.

So what does this mean for the origins of Egyptian civilisation? The trail itself gives only indirect hints of pre-dynastic contact with the region and people far to the west of the Nile valley, but elsewhere firmer evidence is emerging that pharaonic civilisation was underpinned by innovations in the western desert. First there is the important prehistoric settlement of Djara in the centre of the Egyptian limestone plateau, between the western oases and the Nile valley. ACACIA researchers have been excavating there since 1993, and have found a variety of bifacially retouched stone tools, including arrowheads and knives, dated to around 5500 BC. About 500 years later this same technology appears in the Nile valley, suggesting there had been contact between the two regions before the pharaohs' time. "It is clear that influence went from the desert into the valley," Kuper says.

THEY CAME FROM THE WEST

Discoveries made in the Sahara desert west of the Nile show the ancient Egyptians had strong links to the region, suggesting their civilisation may have originated there





Another western desert veteran, Fred Wendorf of the Southern Methodist University in Dallas, Texas, has uncovered hints of the origins of ancient Egyptian religious ideas in the desert. At a key Neolithic site called Nabta Playa, about 100 kilometres west of Abu Simbel, Wendorf and his colleagues have found remains of cattle that seem to have been ceremonially buried, which they have dated to about 7400 years ago. In the early dynastic period in the Nile valley, people also brought hundreds of bull heads to graves. "It seems obvious that this idea of worshipping cattle came from the desert," says Kuper. He points out that later, within the pantheon of gods of ancient Egypt, there is the cow-headed goddess called Hathor. "For the nomad, the cow was the centre of their lives. This ideology may be rooted among the desert pastoralists," he says.

Roots of a civilisation

Wendorf has also found large late-Neolithic sandstone slabs, aligned from north to south, and what appears to be a "calendar circle" of smaller slabs. The use of astronomical knowledge and devices to predict solar events, and an emphasis on cattle in religious beliefs, seems to have a long history at Nabta Playa, he observes. In the Nile valley, by contrast, both appear suddenly at around 3500 BC, in the late pre-dynastic era and early Old Kingdom. For Wendorf, it is clear where they came from.

It wasn't just ideas that spread to the Nile valley from the desert. The ancestors of the valley-dwellers who were united under the first pharaohs also seem to have come from the western desert. In August 2006, Kröpelin and Kuper published a detailed analysis of climate and archaeological data going back 12,000 years, from hundreds of sites across the Sahara (*Science*, vol 313, p 803). About 10,500 years ago, the western desert became more humid – and habitable. The earliest pottery in Africa appears here at around that time, as does the first evidence for the domestication of cattle (though this early date for cattle is disputed). By around 7500 years ago, the rainfall pattern had shifted, and the desert was starting to dry out, forcing people to flee to the oases or the Nile valley. This exodus from the western desert coincides with the rise of settlement along the Nile, they observe in their paper. "We are convinced this was not coincidental," Kröpelin says.

Kröpelin and Kuper suggest that before around 3500 BC the Nile valley may have been too marshy to offer a good permanent residence, but as the climate began to dry it would have become increasingly fertile and attractive. Nick Brooks, assistant director of the Saharan studies programme at the University of East Anglia in the UK, points out in addition that an influx of people into the region would have created a need for greater social organisation and provided a pool of workers for the monumental construction

Until recently the Dakhla oasis was thought to be the most westerly outpost of ancient Egypt

projects and armies initiated by the pharaohs.

Despite prompting a radical rethink about the origins of the pharaonic civilisation, these discoveries have proved remarkably uncontroversial among Egyptologists. The same cannot be said of another of Bergmann's findings. By 2000, he and the three German academics had become close friends and collaborators. Although Bergmann preferred to explore alone, they shared a passion for the desert and would avidly swap ideas. The toughness of the environment helped cement a bond. Temperatures can soar to 60 °C in the heat of the day and then plunge below freezing at night, with a wind chill that makes it feel far colder. Water is scarce, and on at least two occasions Kröpelin and Kuper saved Bergmann's life, they say, by guiding him to their water caches when his supplies had run out. But that December Bergmann found something that would change everything.

He was walking with his camels about 60 kilometres north of the Abu Ballas trail and 60 kilometres south-west of the Dakhla oasis when he came across an unusual flat-topped mountain. At its base was a natural terrace 3 to 4 metres wide and about 40 metres long, artificially enlarged to form a camp ground ▶

"Bergmann thinks this is a form of prehistoric hieroglyphic writing"

for an expedition. On the rock face close to the terrace were some extraordinary inscriptions, including prehistoric rock art and pharaonic hieroglyphs. "There were abundant texts and cartouches," Bergmann says. "It was clear to me that I had made a big discovery,"

Bergmann recalls Kuhlmann's excitement when he took him to see the site in February 2001: "When we arrived, he was startled. He congratulated me." As Kuhlmann translated the texts, their significance became apparent. The longest records an expedition ordered by the 4th-dynasty ruler Khufu – also known as Cheops, the builder of the Great Pyramid at Giza – in which 400 men were sent into the desert to collect something called "mefat". The ACACIA researchers later uncovered extensive evidence of a soldiers' camp at the site, including whole roasted locusts, radiocarbon-dated to 2610 BC. The nature of "mefat"

remains uncertain, though Egyptologists have speculated that was a mineral or vegetable pigment used to paint Khufu's pyramid.

The mysteries do not end there. Among the hieroglyphic inscriptions and earlier rock art are some peculiar ideograms. These show horizontal zigzag or crenellated lines framed by a slightly rounded rectangle, the upper corners of which end in two small humps or in short lines. The zigzag lines resemble the ancient Egyptian hieroglyphic symbol for water, and the humps are similar to the symbol for a mountain. In one, the zigzags have been replaced by a cartouche of Khufu's son Djedefre, leading Bergmann to name the site "Djedefre's water mountain". It seems the ancient Egyptians set up camp around this flat-topped mountain because it would have collected rainwater, which would then slowly leach out, forming springs on its flanks long after rain pools in the desert had dried out.

Bergmann suspects they were not the first to exploit this natural resource. He points to another set of strange inscriptions at the site, which he believes form a map – the oldest ever found – showing 10 wells and several irrigated fields, two connected to a water source. Using this to guide him, Bergmann had no difficulty finding 10 outposts of Djedefre's water mountain, between 6 and 9 kilometres to the south-west, each inscribed with the same zigzag-hump symbols – the wells. What's more, since the "map" is overlaid with a Neolithic-style image of an animal, it seems

to be pre-pharaonic. Bergmann's radical conclusion is that the "water mountain" ideograms represent a form of prehistoric hieroglyphic writing, created by people living at least temporarily in the desert.

This is where Kuhlmann and Bergmann part company. Kuhlmann thinks Bergmann has misinterpreted the findings at the site, especially the hieroglyphs. He maintains that they were made by 4th-dynasty pharaonic expeditions. "There is no comparable representation from a pre-dynastic or even prehistoric context anywhere in Saharan rock art," he says. Bergmann is sticking to his guns. "Kuhlmann turned from friend to foe," he says. His relations with Kuper and Kröpelin have also soured, and he believes they are sidelining him academically.

Despite this rift, the German trio acknowledge that Bergmann's efforts have led to the two greatest pharaonic-era finds in the western desert to date, and Kröpelin supports many of his controversial interpretations. "Despite our bad relationship these days, I would go along with 80 per cent of what he is claiming," he says. "Maybe the roots of hieroglyphs are in the desert." In some respects, Kröpelin is now pushing the boundaries even further than Bergmann. Last March he discovered exactly the same "water mountain" symbols at a site with a flat-topped hill 700 kilometres further south, in the Sudanese desert west of Dongola, suggesting that there were pre-dynastic contacts between Egypt and Sudan. Kröpelin says it also raises the possibility that the water mountain symbol – and even early hieroglyphic writing itself – could have originated in Sudan. He believes his find "should cause a sensation in archaeology" when it is published, but along with Kuper cautions that "more evidence is needed to narrow down speculation".

That means more research. In November 2006, Kröpelin headed to north-east Chad, which remains one of least investigated parts of the Sahara. Kuper and his team have been working at an Egyptian site close to the Libyan border. They are also carrying out more excavations at Djedefre's water mountain.

Bergmann too has returned to the region around the Djedefre site, taking paying tourists to fund his trip. He is also investigating what he thinks are new trails from Dakhla oasis and other pottery sites that he is keeping secret for now, and insists that further great trans-Saharan trails remain to be discovered. "Egyptologists say now that no ancient Egyptian set foot west of Djedefre's water mountain. But they said that about Dakhla, before my discoveries," he says. "It is good for them to have a bit of competition – and to see that what the Egyptologists say might not be the last word." ●



Fragments of pots and amphorae as much as 4300 years old litter parts of the western desert



A bank for the wind

At last we can store vast amounts of wind energy and use it when we need it.

Tim Thwaites reports

Wind farms all too often face a mismatch between the supply of wind and the demand for power

SITTING at the western end of Bass Strait between the Australian mainland and Tasmania, King Island might not seem like a beacon to the future. Yet inside a large metal shed close to the island's west coast is an electricity storage system that promises to transform the role of wind energy.

King Island isn't connected to the mainland power grid, and apart from its own small wind farm it relied for a long time on diesel generators for its electricity. That changed in 2003 when the local utility company installed a mammoth rechargeable battery which ensures that as little wind energy as possible goes to waste. When the wind is strong, the wind farm's turbines generate more electricity than the islanders need. The battery is there to soak up the excess and pump it out again on days when the wind fades and the turbines' output falls. The battery installation has almost halved the quantity of fuel burnt by the diesel generators, saving not only money but also at least 2000 tonnes of carbon dioxide emissions each year.

So what's new? For years wind turbines and solar generators have been linked to back-up batteries that store energy in chemical form. In the lead-acid batteries most commonly used, the chemicals that store the energy remain inside the battery. The difference with the installation on King Island is that when wind power is plentiful the energy-rich chemicals are pumped out of the battery and into storage tanks, allowing fresh chemicals in to soak up more charge. To regenerate the electricity the flow is simply reversed.

Flow batteries like this have the advantage that their storage capacity can be expanded easily and cheaply by building larger tanks and adding more chemicals. The technology is already attracting interest from wind farmers, but flow batteries could also replace all sorts of conventional electricity storage systems – from the batteries in electric cars to large-scale hydroelectric pumped storage reservoirs.

Electricity is very different to commodities like coal or oil that can be stored up in summer ready to meet peak winter demand. With electricity, generating companies meet fluctuating demand by adjusting the supply, from day to day and minute to minute. Typically, they spread the load over large distribution grids and use a mix of huge, ▶

"Drivers could refill the tank with energised vanadium"

economical, "base-load" power stations supplemented by smaller, costlier generators that can be switched on and off at short notice.

Matching supply to demand is particularly problematical when it comes to renewable energy sources like the wind and the sun. The wind doesn't always blow when needed, which means that electricity companies must keep conventional power stations standing by so that on calm days, or when electricity demand leaps, people will still be able to turn on the lights. These power sources can also be difficult to slot in and out of the generation mix. An effective way to store electricity on a large scale would give renewable power sources a welcome boost.

There is no shortage of ways to do this. Ideas range from storing energy underground using hot rocks or storing it as electrical charge in "super capacitors" to using off-peak capacity to pump water into reservoirs where it can drive generator turbines when demand peaks. Then there are various kinds of batteries. While each technology has its advantages, flow batteries seem to have the potential to satisfy the broadest variety of needs – from small power systems to large-scale grid storage – at a competitive price.

Flow batteries are more complex than conventional batteries. In a lead-acid battery, the electrical energy that charges it up is stored as chemical energy inside the battery. Flow batteries, in contrast, use two electrolyte solutions, each with a different "redox potential" – a measure of the electrolyte molecules' affinity for electrons. What's more, the electrolytes are stored in tanks outside the battery. When electricity is needed the two

electrolytes are pumped into separate halves of a reaction chamber, where they are kept apart by a thin membrane. The difference in the redox potential of the two electrolytes drives electric charges through the dividing membrane, generating a current that can be collected by electrodes. The flow of charge tends to even up the redox potentials of the two electrolytes, so a constant flow of electrolyte is needed to maintain the current. However, the electrolytes can be recharged. A current driven by an outside source will reverse the electrochemical reaction and regenerate the electrolytes, which can be pumped back into the tanks.

No more leaks

The installation at King Island has its origins in the 1980s when Maria Skyllas-Kazacos, a young Australian chemical engineer, started a research programme on flow batteries at the University of New South Wales in Sydney. This focused on one of the big weaknesses of these devices. The membranes separating the two electrolytes allowed molecules of electrolyte to leak across. As a result, each solution became increasingly contaminated with the other, reducing the battery's output.

Skyllas-Kazacos's solution to this problem was to use the same chemical element for both electrolytes. She could still provide the required difference in redox potential by ensuring that the element was in different "oxidation states" in the two solutions – in other words its atoms carried different electrical charges. The element she eventually decided on was the metal vanadium, which

can exist in four different charge states – from $V(II)$, in which each vanadium atom has two positive charges, to $V(V)$, with five. Dissolving vanadium pentoxide in dilute sulphuric acid creates a sulphate solution containing almost equal numbers of $V(III)$ and $V(IV)$ ions.

When Skyllas-Kazacos added the solution to the two chambers of her flow battery and connected an outside power supply to the electrodes, she found that the vanadium at the positive electrode changed into the $V(V)$ form while at the negative electrode it all converted to the $V(III)$ form. With the external battery disconnected, electrons flowed spontaneously from the $V(III)$ ions to the $V(V)$ ions and the flow battery generated a current (see Graphic). Best of all, it didn't matter too much if a few vanadium ions on one side of the membrane leaked across to the other: this slightly discharged the battery, but after a recharge the electrolyte on each side was as good as new.

After more than a decade of development, Skyllas-Kazacos's technology was licensed to a Melbourne-based company called Pinnacle VRB, which installed the vanadium flow battery on King Island. With 70,000 litres of vanadium sulphate solution stored in large metal tanks, the battery can deliver 400 kilowatts for 2 hours at a stretch. It has increased the average proportion of wind-derived electricity in the island's grid from about 12 per cent to more than 40 per cent.

It hasn't all been plain sailing, though. For example, engineers have had to solve a perennial problem with flow batteries – how to prevent leaks that allow energy to literally dribble away – as well as working out how to construct long-lasting membranes.

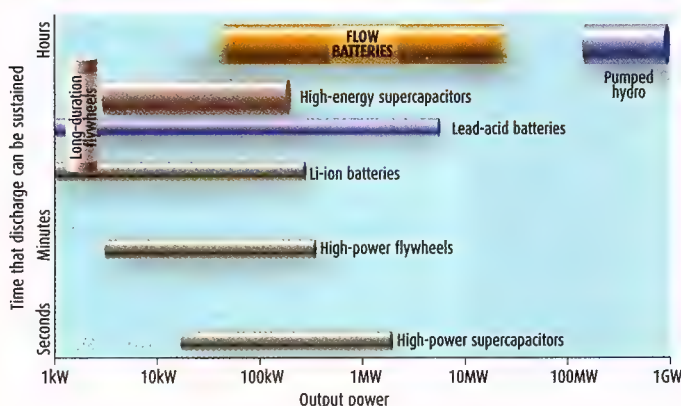
With the installation at King Island up and running, it shows the advantages of vanadium flow batteries over conventional electricity storage. Their working lifetime is limited only by that of the membrane and other hardware, and is expected to be several times the two to three-year lifespan of a lead-acid battery. Like lead-acid batteries, they deliver up to 80 per cent of the electricity used to charge them, but they also maintain this efficiency for years.

One of the key advantages of flow batteries is their scalability. To increase peak power output you add more battery cells, but the amount of energy they will store – and therefore the time they will operate on a full charge – can be expanded almost indefinitely by building bigger tanks and filling them with chemicals. The result is that the batteries can be used in a wide range of roles, from 1-kilowatt-hour units (like a large automotive battery, say), to power-station scales of hundreds of megawatt-hours.

Small vanadium flow batteries are already operating in Japan, where they are used for applications such as back-up power at

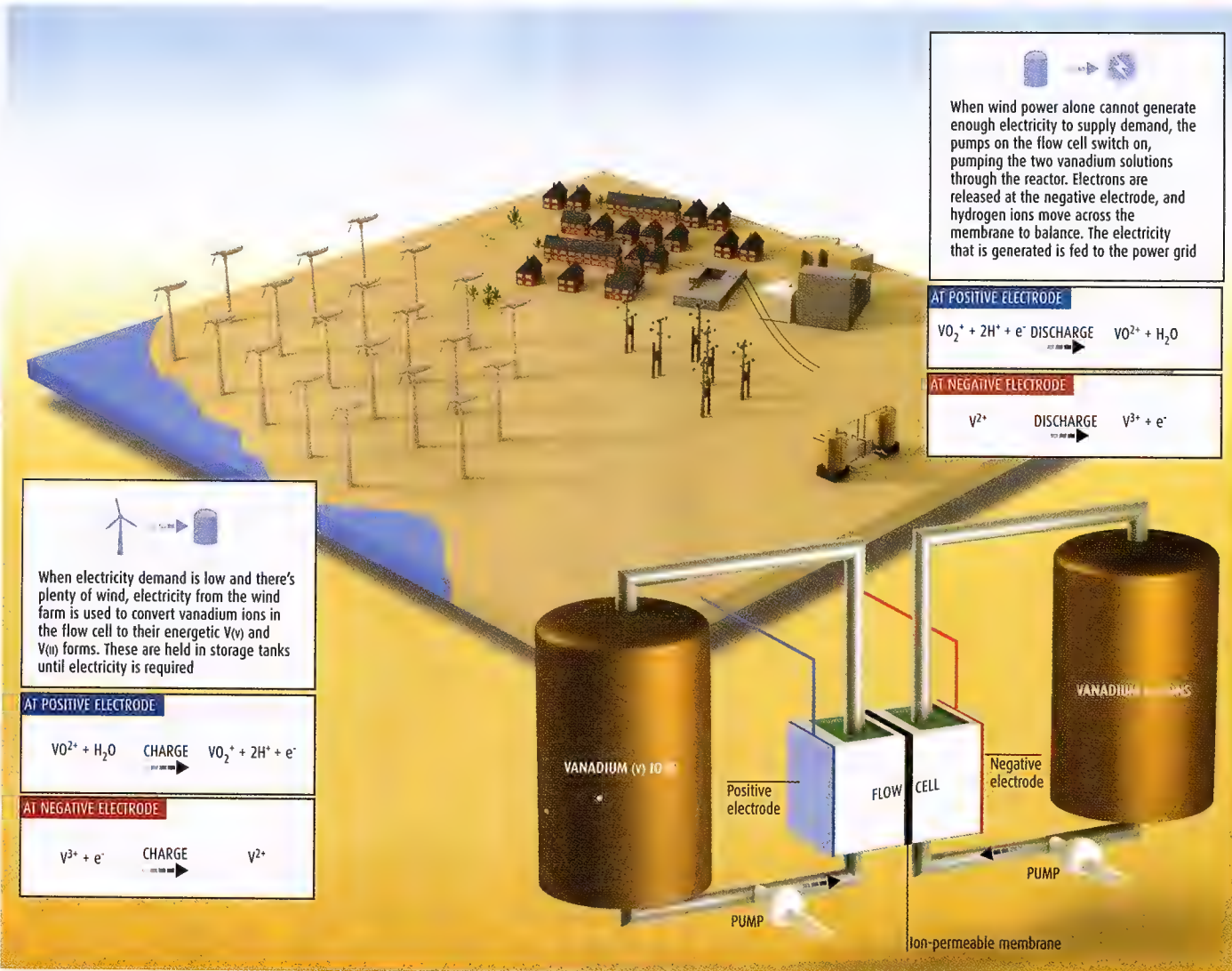
POWER TO THE PEOPLE

Flow batteries are just one technology that can store electricity, but they could be among the cheapest and most versatile for large-scale storage



CATCHING THE WIND

Large rechargeable batteries called vanadium flow batteries can store energy from the wind and release it later as electricity. Potentially cheaper and more efficient than other storage technology, flow batteries promise to transform wind farms into power generators that can supply electricity even when the wind dies



industrial plants. In the US, a 2-megawatt-hour battery installed in Castle Valley in south-east Utah has allowed the local power company PacifiCorp to meet increasing peak power demands without needing to increase the capacity of the ageing 300-kilometre distribution line that feeds the area.

The vanadium-based technology developed at the University of New South Wales is now being put to use by VRB Power Systems, based in Vancouver, Canada. Last year the company signed a \$6.3 million contract to construct a 12-megawatt-hour vanadium battery at the Sorne Hill wind farm in Donegal, Ireland. The idea is to offer a guaranteed supply of wind-generated electricity, and improve the economics of the wind farm by selling stored electricity to the grid at peak times when prices are highest.

The company has commissioned a new production line with the capacity to turn out

2500 5-kilowatt batteries each year. The first dozen of these new batteries are currently under evaluation by customers including the National Research Council Canada and one of North America's biggest cellphone companies.

This is an important stage of development. At present, as with any new technology lacking economies of scale, flow battery systems are more expensive than competing products, but that could change once the new production line is running.

Basic research is continuing too. Vanadium sulphate solutions cannot be made very concentrated so the energy stored in a given volume of vanadium flow batteries is about half that of lead-acid batteries. This rules them out for applications where compactness and low weight are at premium – electric cars being a prime example. So Skyllas-Kazacos and her team want to replace vanadium sulphate with vanadium bromide, which is

more than twice as soluble. She expects that research to be completed by 2008.

VRB Power Systems has already tested its units in electric golf carts. Just as with existing electric vehicles, a car equipped with a flow battery could be charged by plugging it into an electric socket. Enticingly, though, flow batteries might one day allow drivers to refill the tank with energised electrolyte. The spent solution can be recycled.

Whether or not we will one day top up our cars with vanadium, King Island has proved that flow batteries already have a practical role to play, keeping wind-generated electricity humming through the wires even when the breeze drops. You might not even notice it's there – but that's probably the biggest compliment you could pay it. ●

Tim Thwaites is a science journalist based in Melbourne, Australia



You talkin' to me?

Photons are notoriously antisocial, but if you can get them to chat, they turn into

ANDREW GREENTREE wants to play tricks with light. At the University of Melbourne in Australia he's aiming to do something to photons that no one has done before: trap them in cages and make them talk to each other. Unlike particles of matter such as electrons, photons are notoriously unsociable. They pass like ships in the night, even going straight through one another without noticing. Yet if they could be made to interact they might be compelled to form a peculiar new kind of quantum material – one made of light.

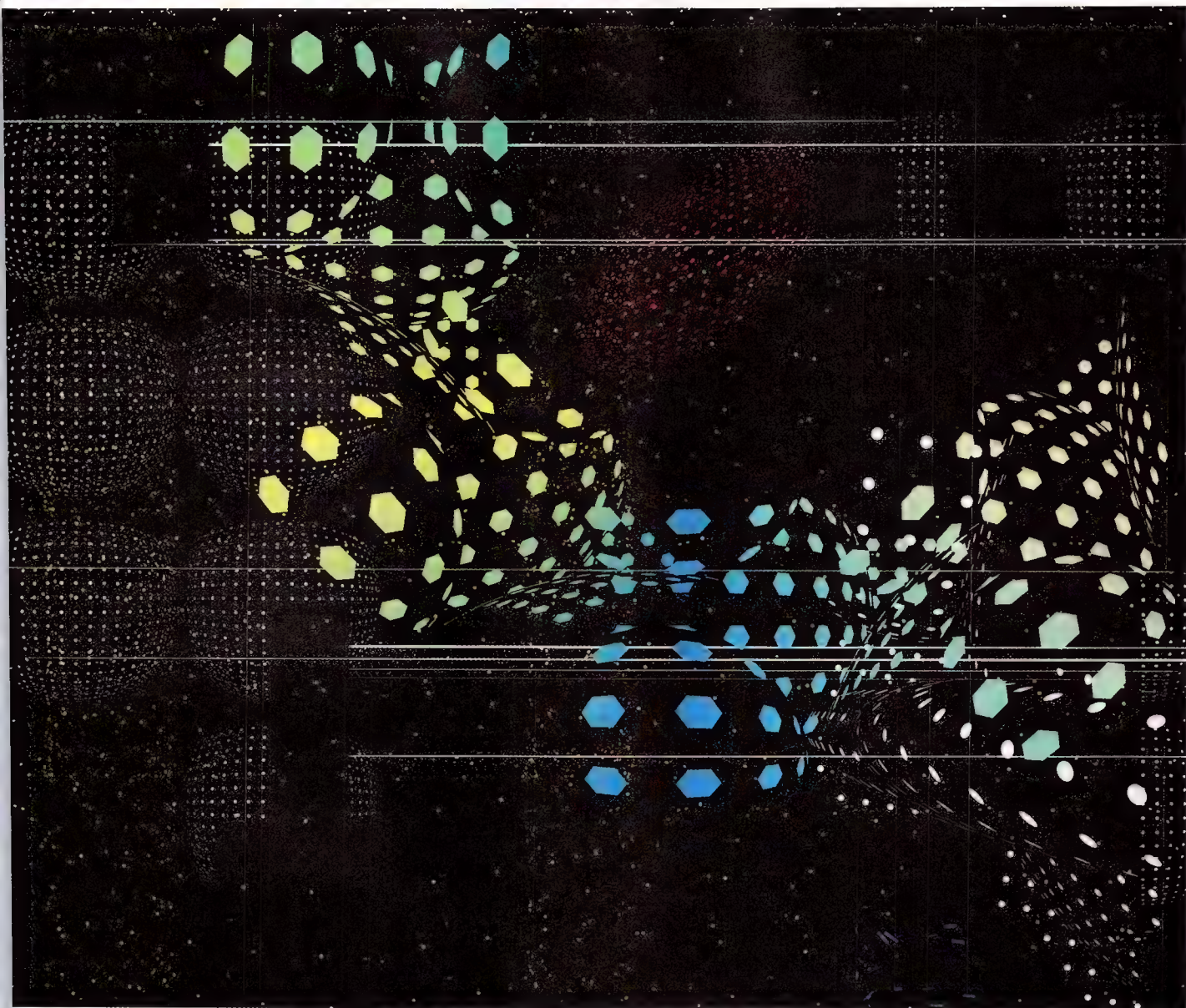
Though this wouldn't be a material in the everyday sense of the word, like a solid you can

touch, it would behave like one in some important ways. Materials get their characteristic properties from the way the atoms within them interact, and the more we know about this, the more we can do with them. Likewise, the way photons interact when they form a quantum material could give us insights into how real materials with quantum properties work. This could, for example, help us explain exactly why high-temperature superconductors can make electricity flow with no resistance at all.

Why is all this important? First, because it may signal the start of a materials revolution that could lead to new kinds of computers and

other devices. Materials made of light could be used to model – and then build – optical circuits that store and process information far faster than anything around at the moment. They may even offer a route to a practical quantum computer – something that as yet exists only in theory – that would be able to perform calculations millions of times faster than a supercomputer.

So far, photon materials also exist only in theory, but there is a buzz of anticipation that they may not be far away. In the past few months, three separate groups, Greentree's among them, have developed models showing that it should be feasible to build and test such



STUDIO TONNE

material made of light. Mark Buchanan investigates

materials within a few years. "The excitement really comes from our ability to make what are essentially new forms of matter," says Charles Tahan of the University of Cambridge, one of Greentree's collaborators.

The idea that light can be manipulated to produce material-like behaviour is not entirely new. In recent years, researchers have experimented with so-called optical lattices, and exploited these devices to model the quantum behaviour of materials. Optical lattices use criss-crossing laser beams to trap and control atoms, which can be kept rigidly in position as if they were in a crystal, or allowed to move and interact freely as

if in a gas. Technical constraints, however, have prevented researchers from studying what happens in these gizmos down to the level of individual particles. Greentree and the others hope to remedy that by building complementary gadgets in which photons act upon each other in more easily measurable ways – and that's the key to the proposed photon materials.

Most of the time, it's a good thing photons don't interact the way atoms and electrons do. It's the reason we can see: light reflecting off a mirror never backs up in a traffic jam, and two crossing flashlight beams never fight with one another. In the air and other ordinary

materials, photons just don't talk to each other. "To make that happen you need to do something special," Greentree says.

Ideas for doing just that have circulated for a decade. In 1997, Ataç Imamoglu at the University of California, Santa Barbara, proposed that a special kind of box or "cavity" could be made to absorb one, and only one, photon. That photon would change the resonant properties of the cavity, preventing it from absorbing further photons, a process called photon blockade. Any photon that enters the system would effectively repel all others. "Put one in," says Dimitris Angelakis of the University of Cambridge, ▶



“and the second one will bounce back.”

In 2005, Jeff Kimble and colleagues at the California Institute of Technology in Pasadena showed a practical way to do this (*Nature*, vol 436, p 87). They built a small cavity between two mirrors, 80 micrometres across, in which only photons of a particular wavelength could exist. To this cavity they added a supercooled caesium atom and showed in experiments that once the cavity-atom complex absorbed one photon, it could not absorb another, because it was no longer in a resonant state that allowed it to attract light.

This striking result spurred three research teams led by Angelakis, Greentree and Martin Plenio of Imperial College London to develop the idea further. Working independently, they began to design full-blown quantum materials out of photons. Their approach, says Angelakis, was to get “light to talk to light through matter”, and to do so in such a way that many photons could be made to interact at the same time (www.arxiv.org/quant-ph/0606159).

What each group now envisions begins with a photonic crystal – a structure that can channel photons rather in the way that an irrigation system controls the flow of water across fields. Made of glass, plastic or diamond, the crystal allows only photons with certain wavelengths to flow inside it. A suitable pattern of holes drilled into the material using an ion beam can create cavities where photons can sit, surrounded by regions where they cannot.

Each cavity then needs something that will produce a photon blockade. Angelakis and Greentree each proposed adding an atom with exactly two energy levels, the difference tuned to match the energy of photons trapped by the cavity (*Nature Physics*, vol 2, p 856). This would produce an array of atom-containing cavities, each capable of taking up

one and only one photon. Add photons to the cavities and they will interact with their nearest neighbours by effectively repelling one another. “You end up with something that looks like a classic material system,” says Greentree, “but made out of light.”

How exactly? In models, the photon materials show behaviours every bit as rich as those of real materials. One of the hallmarks of any material is the ability to change its state – liquid water freezing into solid ice, for example – a process known as a phase

transition. All three research groups have shown that their proposed photon systems would undergo the quantum equivalent of a phase transition, from a so-called “Mott insulating” state, with a photon contained in each cavity unable to move, to a strikingly different “superfluid” state, in which each photon can flow without resistance over the entire array, like an electron in a superconductor.

This effect really proves the principle. “It’s been an open question for a long time as to whether you could ever see a quantum phase transition for light,” says Angelakis. The answer, it seems, is a resounding yes. The transition could be triggered by changing the energy levels of the two-level atoms so that the atom-cavity systems no longer produce photon blockade. That could be induced in a fraction of a second by shining a laser onto all the cavities at the same time.

Plenio’s team go further. They reckon that each cavity could contain not one but an ensemble of atoms, and have shown that photon blockade can be realised by

“You end up with something that looks like a classic material, but made of light”

driving the atoms with laser light (*Nature Physics*, vol 2, p 849). Each group has confirmed in calculations that the behaviour of any photon in the array is intimately linked to the behaviour of others, as is the case with particles that make up liquids, solids and other states of matter. “The interactions are so strong in such systems,” says Gerard Milburn of the University of Queensland, Australia, “that thinking in terms of the bits, the particles, that make them up can be misleading. You need an effective

HOW TO MAKE MATERIALS OUT OF LIGHT

If photons can be made to interact, the resulting "material" could form the basis of a quantum computer or simulator. One idea is to place atoms inside cavities in a photonic crystal. Each atom-cavity can be tuned to absorb exactly one photon and reject others, a condition known as "photon blockade". Disturbing this causes a phase transition – one of the hallmarks of a material.

1. Material is a "photon insulator"

When photon blockade is in effect, each atom-cavity can hold only one photon. This makes it hard for photons to move around. If enough are present, they become locked in place.

2. Phase transition

Shining a laser on each atom-cavity makes the photon blockade vanish, so the photon material changes state...

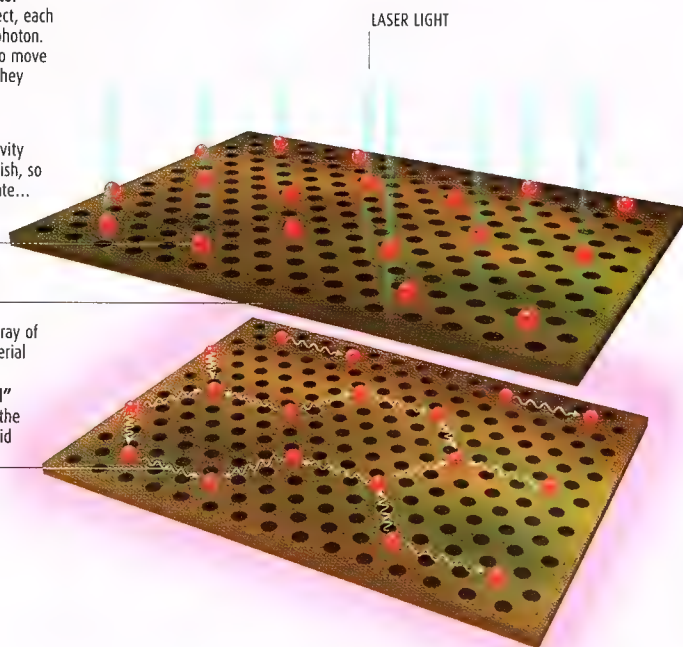
ATOM-CAVITY
can hold one photon

PHOTONIC CRYSTAL
formed by drilling an array of holes in a sheet of material

3. Photons become "superfluid"

Photons flow freely throughout the array, like particles in a superfluid.

PHOTON



Computing by light

The ability to make photons interact could make less traditional schemes for quantum computing more practical. In 2001, Robert Raussendorf and Hans Briegel of the Ludwig Maximilian University in Munich, Germany, proposed that quantum computing might be more easily realised by packing all the quantum links or "entanglements" into one initial step. They showed theoretically that if a number of quantum particles were set up in a highly entangled state known as a cluster state, then any quantum computation could be carried out by making a sequence of simple measurements on the individual particles.

Researchers have since created experimental cluster states involving up to four photons, and have recently proposed ideas for scaling up the process using photons to entangle stationary quantum bits, or qubits (*New Scientist*, 25 March 2006, p 42). Carrying out useful calculations will require more complex cluster states, though, and that's tough.

Michael Hartmann at Imperial College London suggests that his team's proposed quantum material, in which the interactions between photons in an array of optical cavities can be adjusted quite flexibly, might help. Using such a model, researchers could design the photon interactions specifically to create large numbers of entangled qubits. "This should make it more straightforward," Hartmann says.

theory for the system as a whole."

"This is really elegant work," says Pieter Kok at the University of Oxford. "It will be fascinating if they can show it experimentally." If that can be done, physicists will have a new tool to help them understand a range of weird quantum effects. Richard Feynman first suggested in 1981 that simulations of quantum systems such as photons and electrons could best be carried out with other quantum systems: you should simulate like with like. With a "quantum

simulator" made of interacting photons, researchers might gain clues into the baffling nature of high-temperature superconductors and other exotic materials in which strong quantum interactions play a dominant role.

It is thought, for instance, that the bizarre behaviour of such materials might have something to do with what goes on when a system is close to the boundary of a quantum phase transition, such as the transition from Mott insulator to superfluid. At such a boundary, fluctuations in the microscopic

organisation of a material become unusually large and seem to dominate the system's properties (*New Scientist*, 28 January 2006, p 40). At the moment researchers have few techniques for probing the fine details of this state in real materials. "We haven't yet cracked the basic rules," says Jan Zaenen of Leiden University in the Netherlands. "There's a great demand for well-controlled experimental models of these systems. This light stuff might work."

A quantum simulator could also be an important step towards the fabled quantum computer (see "Computing by light"). That's because these simulators can be thought of as rudimentary computers which carry out calculations in strictly quantum terms.

But how to actually build one? Greentree's team proposes that an alternative and promising way to construct photon materials would be to use not two-level atoms in cavities, but defects in the crystal lattice of thin sheets of diamond. These defects – created where a nitrogen atom replaces a carbon atom next to a vacant spot in the lattice – can bind an electron and act like simple atoms. A system of this sort would naturally have many quantum bits, or qubits, that could be exploited to do computations.

Greentree and his colleagues have started working on this idea. They believe they can build the right kinds of devices within a few years, using existing fabrication techniques. "We've never made something this complicated," Greentree admits, "but it is like things being made in silicon already. We certainly think it should be feasible." The end result could be a quantum computer made of diamond.

Even if this proves impossible, Greentree and the others won't be too upset. "There is so much we still have to learn about quantum computing," he says, "that I hesitate to make any predictions. This is a great toy to let us understand new physics. We can combine things in new ways and see brand-new effects, hopefully ones never seen before." ●

Mark Buchanan's book *Small World: Uncovering nature's hidden networks* is published by Weidenfeld & Nicolson

Win or lose, it's fighting back that counts

China's runaway economic growth has made many people rich, but has also left a trail of environmental damage. The farmers, fishermen and villagers whose homes and livelihoods have been harmed by unregulated industries have for years fought in vain for compensation. Now they have a champion in **Zhang Jingjing**, a crusading lawyer at the Centre for Legal Assistance to Pollution Victims, based in Beijing. Zhang spends much of her time travelling to affected villages to meet victims and gather evidence to fight the polluters. She explains to **Diane Martindale** how she goes about helping local people take on the country's all-powerful bureaucracy.

How seriously is industrial pollution damaging lives in the countryside?

I have just come back from the ancient city of Bozhou in Anhui province, where discharges from the factories are so toxic they have killed crops, animals and even people. We met fishermen along the Guo He river, which has become polluted with waste from a nearby leather tanning factory. A few years ago, villagers could swim in the river. Now they get blisters on their hands and feet from touching the water. The river has no fish at all, so the fishermen have lost their livelihood.

When you stand close to the river you can smell rotting flesh because the leather factory dumps its sewage, made up of animal skin and meat, untreated into the river. The farmers have stopped using river water to irrigate their fields because they found that when they do, the crops die. The tanning facility has the equipment to treat sewage, but the villagers say the company doesn't use it because it is too expensive. They say the factory has a big

discharge outlet at its warehouse, and when no one is looking they pour waste in the river.

We came to get proof. We found the sewage discharge exit, which we videotaped, and we collected samples of the silt to test for two toxic metals, chromium and cadmium, used in tanning. We will use this evidence in court.

What motivated you to become an environmental crusader at a small legal-aid clinic?

It happened while I was working as a foreign investment lawyer in a big firm in 2000. My Taiwanese client planned to open a dye works at the head of the Dong Jiang river, which provides drinking water to Hong Kong. The local authorities reassured my client that his company did not need to worry about the environmental impact assessment because the government would help the company get all the necessary permissions. It struck me how common and easy it had become for local government to sacrifice the environment to attract investors. Many officials are more

Profile

Zhang Jingjing obtained her law degree in China and completed a fellowship at Columbia University in New York. She started working with the Centre for Legal Assistance to Pollution Victims in 1999, as a volunteer. At 37, she is now the centre's director of legal affairs. Zhang knows first-hand what it's like to live near toxic waste: she grew up on the grounds of a vast chemical factory in the western city of Chengdu.

concerned with money than with the environment and people's health. At the same time, I was volunteering for the Centre for Legal Assistance to Pollution Victims (CLAPV) in Beijing. Gradually, I devoted more and more time to public interest cases.

What systems are in place to protect the environment in China?

There's the environmental impact assessment or EIA, which became effective on 1 September





For Zhang Jingjing, the fight against pollution begins by persuading local people that they are not powerless

They are more aware of their rights now. Our work is also making the Chinese public more conscious of environmental issues.

How has the government reacted to your work?

For the most part the central government does not oppose our efforts, as long as there is no interest group putting pressure on it. Still, it is always slow to respond. No government, whether local or central, is willing to release bad news about the environment. However, the central government has recognised that pollution is a big issue and that it harms the “harmonious society” called for by the Communist Party. The provincial governments are different: they still sacrifice the environment to attract investors.

What are your biggest challenges in fighting these cases?

One of the main obstacles is our judicial system. China has only recently created the rule of law; it is a new concept for everyone. The authorities don't always accept that it applies to them. This takes time. Often, the local government or other interest groups will interfere and influence the courts and judges. Another problem is the public's lack of knowledge and information. Many victims of pollution don't think litigation can help them, and they don't have money to file complaints. There's also the lack of evidence. The government sometimes denies our requests for information.

What can you do then?

Sometimes there is nothing we can do. But we don't give up easily.

How difficult can it get?

In 2001, the Chinese government built a dozen or so chemical plants near the southern town of Huaxi in Zhejiang province. Soon after, a nearby village's river turned brown and there was an increase in stillborn babies. The villagers petitioned many times to reclaim the land, which they say was illegally seized. After four years of being ignored, they took matters into their own hands. On 10 April 2005 they barricaded the road to the plants. When police arrived, they faced 20,000 angry people who attacked them, overturned their cars and drove them out of town – after which the central government stepped up security there. When we got involved, the government denied our requests for environmental reports. Because security was so high, I had to sneak in at night to speak to the villagers. ●

2003. This is a legal system designed to analyse the possible impact on the environment of new factories or businesses. When developers want to set up a new project they are expected to submit an EIA report to the local government before the project starts.

Is the new system making a difference?

Many companies ignore it, but we do have some success. For example, people in a neighbourhood in the northern port city of Tianjin were plagued by the noxious, untreated exhaust of a coal-burning heating plant. The owner of the plant, a real-estate developer affiliated with the local government, simply ignored the residents' repeated complaints and then began building a second plant. The frustrated residents got together and blocked the road to the new plant, which effectively shut down the construction work. The company responded by suing the activists for 600,000 yuan (about \$70,000) in damages.

When we looked into this case, we discovered the company had violated regulations because they had let more than five years lapse between getting the new plant approved and building it. With this evidence, plus the media attention that the case generated, the company backed down: it not only dropped the suit, but also paid the residents 100,000 yuan in compensation. What was a real triumph, though, was that the company implemented a cleaner design for the new heating plant.

How often do you win against the polluters?

We win about half our cases.

That sounds as if it might be discouraging.

Winning or losing is not what's most important right now. The litigation itself is a victory because it means the courts are accepting the cases. That alone is encouraging. And the whole procedure is a process of legal education for the villagers that we defend.

Between a rock and a hard place

For years, the frustrating lack of progress on the problem of free will has been a scandal in philosophy. Now it looks as if neurobiology may help us out – and indeed it may, says **John Searle**, but don't think for a minute you'll be able to live with the result.

SOME traditional philosophical problems – unfortunately not many – can be solved scientifically. Among them is the problem of what it means for matter to be alive, where scientific explanations are now sufficiently good that we cannot recover the passion with which this was debated by our great grandparents.

Another problem on the way to a solution is consciousness. This is a problem for much the same reasons that thinking about life is: how can the brain, a biological (material) mechanism, cause conscious (apparently immaterial) states, and how are those states realised in the brain?

Next to consciousness is the even trickier “free will” problem. Could there be a scientific solution? The problem of free will is how to reconcile our experience of our free actions with what we believe about causation. Our general approach to reality seems to presuppose causal determinism. If you ask why the Oakland freeway collapsed in 1989, I can tell you about the Loma Prieta

earthquake. Given the way the causes worked, the freeway “had” to collapse; the causes were “sufficient” for it to collapse.

Because we assume there must be some such story for all events, including human actions, there seems to be an easy solution to free will: it does not exist. All our actions are caused. They have causally sufficient conditions which determine that the actions happen once the causes happen. Why can't we just accept that and go home?

The reason is that it is part of our conscious experience of voluntary intentional action that we can only proceed on the assumption of free will. If you believe that rainbows are systematic illusions, you can lead your life consistently on that basis. But if you believe that free will is an illusion, you cannot live your life on that basis.

Try this. You are in a restaurant and the menu has only two items to choose from: veal scaloppini or spaghetti bolognese. You cannot say to the waiter: “Look, I am a determinist. I know my order is determined, so I will wait and see what I order. *Che sarà, sarà.*”

Now why not? Because your answer is only intelligible to you if you assume that giving it was a free action on your part: you did not wait for your mouth to open and for these noises to come out, and you experienced the saying of the words as a manifestation of the freedom we are examining. Action is unlike perception. What you see on the menu is experienced as being not up to you: it is fixed both by your own perceptual apparatus and by the impact of the external stimulus (the menu options) on that apparatus. What you

decide to do about those options, on the other hand, is experienced as being up to you.

So we are stuck with the presupposition of free will, even if we embrace determinism. It is a feature of conscious human thinking, deciding and acting that we experience these activities not as causally continuous, but as containing causal gaps. These gaps are the perceived absence of causally sufficient conditions. I will not experience the gaps if someone shoves me into the English Channel, but I will if I set out to swim it.

In that case, there is a perceived gap between considering whether or not to swim the Channel, and making up my mind to do it. There is another gap between making up my mind and jumping in. And there is a third between jumping in and completing it. All three are parts of a single continuous gap in free, voluntary, conscious action. We cannot shake off the conviction of free will because we cannot shake off the experience of the gap. But is the gap real or illusory?

All our conscious states, including our conscious experience of the gap, are caused by neurobiological processes. At the conscious level we experience freedom because we sense we have alternatives, and that our actions are not fixed by prior causal conditions. At the neurobiological level, all of those experiences are fixed by brain processes.

So if the experience of freedom is real, there must be an indeterminism in the brain corresponding to the gaps. If free will is real, there cannot be causally sufficient neurobiological conditions moving us from contemplating alternatives to deciding

Profile

John Searle is Slusser Professor of Philosophy at the University of California, Berkeley. He has written 17 books, including his Reith Lecture series, *Minds, Brains and Science* (Penguin/Harvard). His “Chinese room” argument attracted much attention by trying to show that digital computation by itself is not sufficient for thinking – that there is more to thinking and understanding than manipulating symbols. This essay is based on his latest book, *Freedom and Neurobiology*, just published by Columbia University Press.



real. For that to be possible, there would have to be some indeterminism, some lack of causally sufficient conditions in nature.

As far as we know, the only established indeterminism in nature is quantum mechanics. But at the quantum level, the absence of causally sufficient conditions produces randomness, and randomness is not the same as free will. (Contrary to popular opinion, determinism is not the natural, or default, position in nature. Quantum indeterminacies are built into the structure of the universe from top to bottom, but tend to cancel themselves out at the macro level.)

So with Hypothesis Two, when the machine produces conscious decision-making, it would have to produce the indeterminacy of the quantum level without its randomness. I am not sure that this makes sense in physics, but it is the best I can do, if I treat the existence of free will as a serious possibility in neurobiology.

Now, if we had to choose between the two hypotheses, we would surely bet on Hypothesis One, given what we know about the world. The only argument I can think of against it is that it is totally unlike biological

“Determinism is not the natural or default position in nature”

evolution to give us an extremely costly phenotype (conscious rational decision-making) that plays no role in the survival of the organism. We have to suppose that the enormous blood flow to the conscious brain, and the enormous time spent educating the young to make rational decisions, makes no difference, since all decisions are fixed by deterministic neuronal processes.

If Hypothesis One runs dead counter to evolution, Hypothesis Two is consistent with our experiences, but seems crazy. Besides, it gives us three mysteries for one: to solve the mystery of free will, you have to solve the mystery of consciousness, and you do that by relying on the mystery of quantum mechanics. Hypothesis One is consistent with our scientific view of how the world works, but we cannot live with it.

When I discussed these issues in a lecture in London, someone in the audience asked: “If Hypothesis One were demonstrated to be true, would you accept it?” Notice the form of the question: if it were demonstrated that there is no such thing as free, rational decision making, would you freely and rationally decide to accept that demonstration? ●

between them. To suppose that free will is not an illusion is to suppose that the “gaps” in our thought processes are paralleled by “gaps” in neurobiology. But the brain has no gaps.

Two hypotheses emerge. Hypothesis One says that free will is an illusion, that our consciousness of free action is as illusory as our experience of rainbows as “real” objects. Hypothesis Two says that our experience of free will reflects something real in the brain mechanisms that produce and sustain consciousness. But what could that mean?

Let us consider the problem in engineering terms: how would you design a machine capable of knowledge, ethical behaviour and the sense of free will? Using Hypothesis One, the machine has to be conscious and experience free will, though it lacks it. It has to experience the gaps, though its decision-making process makes no difference to the outcome. With Hypothesis Two, however, the machine’s decision-making process does make a difference. The gap is not only psychologically real, it is neurobiologically

Poe's cure for death



One spring evening in 1908 three doctors stood before an expectant audience in the library of the Medical Society of the County of Kings in Brooklyn, New York. Before they began their demonstration, they needed one last thing. "Fetch a stray dog," they cried, tossing a quarter to an urchin outside. The boy returned with a yelping yellow mutt, which the doctors gently petted until it wagged its tail. Then they hog-tied and smothered it. The dog struggled for a few agonised minutes before giving a low moan and going limp. It was a scene worthy of Poe – not the great master of the macabre, Edgar Allan Poe, but his cousin George. For he had promised the audience a feat befitting his family name: this dog would be brought back from the dead.

GEORGE POE had little if any memory of cousin Edgar: he had been just 3 years old when his famous relative was found delirious and dying on the streets of Baltimore in 1849. He had, however, inherited the Poe fascination with science and intoxicants: after fighting in the civil war, George built the Poe Chemical Works in Trenton, New Jersey, where he designed America's first plant for mass-producing liquefied nitrous oxide. By 1883 Poe was supplying some 5000 dentists across the country with cylinders of laughing gas, including one suspiciously enthusiastic client in Cleveland who ordered 4000 gallons. But deep inside his chemical works, Poe was pondering a question worthy of old cousin Edgar: could the dead be restored to life?

The question was not a fanciful one. Poe himself had witnessed a relative who had been declared dead suddenly come gasping back to life. With a vast laboratory and a gas production line at his disposal, Poe began experimenting with tubing and cylinders of oxygen to see if he could restore breathing.

First, naturally, he needed some dead to revive. Poe suddenly took an unusually keen interest in the local rabbits. He would chloroform them to the point of death and then insert flexible tubes into their nostrils or down their throats: one tube supplied oxygen to the lungs from a carefully regulated tank, while another sucked air out. Inhalation and exhalation from the animals' limp forms was driven by a handle or a treadle working two brass pistons. With some tinkering, Poe fashioned an apparatus that worked; perhaps a little too well for one particularly unlucky

rabbit that was suffocated and revived 11 times during its career at Poe's Chemical Works.

If it worked on a rabbit, would it also work on something bigger – say, man's best friend? Or, indeed, on a man?

Artificial respiration had itself needed reviving many times over the centuries. Italian peasants employed mouth-to-mouth resuscitation on newborn babies as early as the 1400s, and in 1555 anatomist Andreas Vesalius described how he revived animals with bellows via a tracheotomy. The following century in Britain, Robert Hooke performed similar experiments on dogs. Yet it was not until the 18th century that mouth-to-mouth

"Townsfolk ascribed almost supernatural powers to Poe"

and respirator devices gained currency. Acceptance had perhaps been slowed by fears that successful revivals might too easily lead to accusations of witchcraft.

The usefulness of such methods could scarcely be denied, however. In 1744, Scottish physician William Tossach wrote a case study describing how he had revived an asphyxiated coal miner called James Blair. By 1767 a Dutch society for reviving drowning victims had formed in Amsterdam. Then, in 1774, London followed suit with the Society for the Recovery of Persons Apparently Drowned, later known as the Royal Humane Society. In the early days, the RHS concentrated on establishing

riverside emergency stations equipped with respiration kits. A typical kit in 1782 included a half-litre bellows and elastic tubing, as well as a thin leather tube for funnelling or blowing restorative medicines directly into the stomach. The society records that in its first 20 years its efforts saved 1835 lives.

Opinion remained divided as to the merits of mouth-to-mouth versus artificial respirators. By the 1830s bellows had fallen out of favour because of concerns about overinflating the lungs, although as early as 1838 there had appeared a crude "pneumatic cuirass" that surrounded the thorax with subatmospheric pressure to induce the chest itself to expand like a bellows – a prototype of the iron lung. In time both mouth-to-mouth and machines would prove their worth, though in the US full acceptance of mouth-to-mouth did not come until 1958. Some devices were abandoned, though: one rather alarming tool distributed by the RHS for stimulating victims was a rectal fumigator, a bellows that blew tobacco smoke up the anus.

Poe's contraption was gentle by comparison. In 1889, he went on a nationwide tour to show off his invention, amazing audiences by gassing rats and rabbits then reviving them and sending them scurrying off the stage. His device, he stressed, wasn't just good for reviving victims of drowning. In the era of the gas lamp there were all too many deaths from gassing – both accidental and deliberate. "The principal use of the machine," Poe explained, would be "in hotels where the gas is blown out, and in lodging houses".

His tour propelled the contraption into the

You can find out more about the work of the Royal Humane Society by visiting www.royalhumane.org



headlines: "It Brings the Dead to Life" was typical. Still others envisioned less mortal uses. "A man in a drunken stupor," *The Technical World Magazine* reported rather hopefully, "may be quickly sobered by using the machine to quicken his respiration."

Then, just as mysteriously as he had appeared, Poe suddenly disappeared. "What has become of Poe's great invention?" demanded the *Decatur Daily Review*, and others across the country took up the call. Poe issued no reply.

Instead, he returned to his old home state of Virginia, buying a house in South Norfolk and, locals whispered, continuing his experiments there. Townsfolk ascribed almost supernatural powers to him. One heartbreaking letter from an 8-year-old girl was typical: "Dear Professor Poe, My three-year-old brother died six months ago, and my mamma has been so sad ever since and cries for him. If we sent our little brother to you, do you think you could make him alive again? Mamma has \$1.50 we made by picking berries and washing and you can have it."

If anyone now needed reviving, though, it was Poe himself. By the turn of the century, illness had left him nearly blind and partially paralysed. Despite this he had one last mighty

effort left in him: after almost two decades of silence he made a surprise announcement in 1907 that he would begin demonstrating his invention once again.

So it was that a hush fell over the crowd of Brooklynites in their medical society's library. Doctors inserted the tubes into the stray dog's windpipe and pumped the respirator handle. The dog's chest rose and fell. Minutes passed. A leg twitched, then another, and then the dog began to kick. Ten minutes after "dying", reported *The New York Times*, the dog staggered to its feet.

Such demonstrations were so convincing that one Harriet Martin of Chicago publicly offered to be Poe's first human guinea pig. Poe politely declined. "Poe says he is grateful for the offer," reported one newspaper, "but to utilize the woman he would have to kill her and he is afraid to take the chance."

Even so, there was no lack of places where such chances might be taken. "Lifesaving stations and ambulances will eventually be equipped," Poe announced, "and I feel confident that the legislature of every state will compel every hotel to have one, the same as they require fire escapes now."

Just as Poe was regaining his fame, however, it slipped away once more.

George Poe's device was intended to revive victims of both drowning and gassing

His health worsened, while other inventors developed their own artificial respirators, an endeavour that gained urgency with the onset of the first world war and the horrors of gas attacks. When Poe died in 1914, obituaries mentioned how once there had even been talk of a Nobel prize. But with that he vanished from the public's memory: scarcely another word has been written about him.

His invention was not entirely a failure, though. Among the local news from Norfolk in March 1909, when Poe had retired to his sickbed, is word of "the thrilling experience of Moses Goodman". Found nearly lifeless in his gas-filled home, Goodman was rushed to the local hospital. His case appeared hopeless until the supervising physician recalled that an old prototype Poe respirator had been left in the building. It still hadn't been tried on humans, but there was little left to lose. The discarded arrangement of tubes was attached and the old pumps engaged. To everyone's astonishment, the patient revived.

And so to Moses Goodman, perhaps, belongs this unique distinction: a Poe story with a happy ending. **Paul Collins** ●

The word

Yocto

IT SOUNDS like a creature from a sci-fi movie, but yocto is both more and less exotic than that: it's a numerical prefix denoting an extremely small number.

To save writing all those zeros when noting very small or large amounts, scientists devised some short-cut prefixes. But while we've all heard of a milligram (a thousandth of a gram), a kilometre (a thousand metres) and perhaps a gigawatt (a billion watts), what about a yoctogram? It is 10^{-24} of a gram, about 60 per cent of the mass of a neutron. And yocto, along with yotta (10^{24} – the digit 1 followed by 24 zeros), are the most extreme prefixes used as multipliers for metric units.

Where did the name come from? The older prefixes – from milli to kilo – date back to 1795, when the French Revolution gave birth to metric units. Milli and kilo come from the Latin and Greek terms for a thousand. In 1875, the International Bureau of Weights and Measures was established in Paris to standardise this as a global scientific system.

As science marched on to smaller and bigger things, more prefixes were needed. By 1975 the Paris bureau had authorised prefixes from peta (10^{15}) down to atto (10^{-18}). After giga (10^9), tera (10^{12}) and nano (10^{-9}) had been coined from the Greek for giant, monster and dwarf, the bureau's sages were running out of



classically derived terms. So they used the Nordic words for 15 and 18 for femto (10^{-15}) and atto.

After that, some lateral thinking was needed. Take 10^{15} . This can be written as 1000^5 , so it was called peta, from the Greek for five, *penta*.

Yocto got its name in an even more convoluted way: 10^{-24} is equivalent to 1000^{-8} , and the Greek term for 8 is *okto*. The "o" from *okto*, however, could be confused with a zero, so the sages

"As science moved on to smaller and bigger things, more prefixes were needed"

added a "y". At the big end of the prefixes, yotta is a variation of the Latin or Italian for eight.

At the moment yotta and yocto are the largest and smallest official prefixes, but will they continue to hold this position? An electron weighs around a thousandth of a yoctogram. Could this be named a xontogram, moving one letter along from yotta and based on *nonus*, Latin for nine? Earth's mass is 6000 yottagrams – or perhaps one day, Paris willing, 6 xonograms? This model allows plenty of alphabetic alterations of Latin numbers to expand into. But will science ever work at a small enough level for a pekrogram (10^{-51}) or big enough for sortagrams (10^{42})? ●

Enigma

Spell check

No. 1425 Susan Denham

IN THE following statements and question each digit has consistently been replaced by a capital letter, with different letters used for different digits.

ONE, FOUR and NINE are perfect squares. Also, more than one of the following

statements is true: EIGHT is even; EIGHT + 1 is a perfect square; EIGHT + ONE is a perfect square; EIGHT - 1 is a prime; EIGHT - ONE is a prime; EIGHT + 7 is the product of two primes; EIGHTEEN is divisible by 3; EIGHTEEN is divisible by THREE; EIGHTEEN - 2 is a perfect square.

What is the RIGHT number?

£15 will be awarded to the sender of the first

correct answer opened on 14 February. The Editor's decision is final. Please send entries to Enigma 1425, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (include your postal address). The winner of Enigma 1419 is Ed DeLorenzo of Brooklyn, New York, US.

Answer to 1419 lying about my age I am 64 years old.

Bookends

Ornithologist's bible

Birds of Northern South America
by Robin Restall, Clemencia Rodner
and Miguel Lentino, Helm Field Guides,
ISBN 0713672420
Reviewed by Adrian Barnett



WITH so much of northern South America still uncharted, ornithologists have long required an unequivocal identification guide for the region's feathered fauna. These two volumes provide a fine distillation of experience and fact. One is dedicated to field-savvy descriptions, while the other contains maps and illustrations for the area's 2300-plus bird species. I can attest that the guide performed wonderfully in Brazil's Jau National Park. It should become as essential as binoculars for anyone who studies birds in the region.

It's that simple

The Seven Secrets of How to Think Like a Rocket Scientist

by James Longuski, Springer,
ISBN 0387308768

Reviewed by Jonathan Beard



"ROCKET science" has become a synonym for complexity, but there is nothing complicated about this book. With short chapters made up of bromides, slogans and quotes from popular books, it amounts to a list of the author's likes – the early years of *Star Trek* – and dislikes – the space shuttle. The ideas he shares, such as "use your imagination" and "have a back-up plan" are rife in many self-help books. Longuski knows about rocket science: he worked for NASA optimising spacecraft control for long missions. Sadly, he has little new to say.

Who says 13 is an unlucky number?

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13 FACTS ABOUT 13

The 13th root is the most famous integer root calculation record, because 13 is the first prime number over 10 such as the last digit of a 13th integer power is the same as the last digit of its 13th root

The known universe is currently thought to be about 13.7 billion years old, with an error of about one percent

There are 13 zodiac constellations, which consist of the 12 signs in the astrological zodiac and Ophiuchus

The New General Catalogue object NGC 13 is a spiral galaxy in the Andromeda constellation

The expression "A year and a day" refers to 13 28-day lunar months plus 1 day

The number of cards in a single suit of a standard deck of playing cards

Unreasoned fear of the number 13 is termed triskaidekaphobia

In 13 A.D. Strabo published his view on the shape of the Earth

The number of dimensions in some theories of relativity

The number of loaves in a "baker's dozen"

The 13th moon of Jupiter is Elara

The atomic number of aluminium

There are 13 Archimedean solids



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The successful appointee will be passionate about communicating science and its promotion and popularisation in the community. They will have an exemplary international research reputation, a capacity to provide academic vision and strategic leadership, and the ability to work with staff from diverse academic and cultural backgrounds. It is expected that links with other academic units throughout the University will be initiated and fostered, and that strong associations with the appointee's primary research area will be maintained to promote continued scholarship there as well as publications directed at science communication.

Further information about the University of Otago can be found at <http://www.otago.ac.nz>

Specific enquiries may be directed to Professor Vernon Squire, Pro-Vice-Chancellor, Sciences, Tel 64 3 479 7977, Email vernon.squire@otago.ac.nz

Reference Number: A06/214.

Closing Date: Wednesday 31 January 2007.

APPLICATION INFORMATION

With each application you must include an application form, an EEO Information Statement, a covering letter, contact details for three referees and one copy of your full curriculum vitae. For an application form, EEO Information Statement and a full job description go to: www.otago.ac.nz/jobs Alternatively, contact the Human Resources Division, Tel 64 3 479 8269, Fax 64 3 479 8279, Email job.applications@otago.ac.nz



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Australian Government

Department of the Environment and Heritage

COMMONWEALTH ENVIRONMENT RESEARCH FACILITIES (CERF) Call for applications for Fellowships and Significant Projects

The Australian Government Department of the Environment and Heritage invites applications for research fellowships and significant research projects under the second funding cycle of the CERF programme.

Research fellowship applications are sought from world-class scientists (Australian or international) to work within an Australian institution. Significant project applications are sought from existing Australian research institutions for research of up to three years.

CERF targets world-class, public good, collaborative research that focuses on CERF priority research areas. It is primarily aimed at areas that have not yet received substantial assistance and encourages co-investment.

This funding round will be based directly on applications and will not have an expression of interest phase. For further information, including application guidelines and forms, visit: www.deh.gov.au/cerf/

Applicants are required to submit an online application form:

- fellowship applications should be submitted to CERFfellowships@erin.gov.au by close of business on Friday 16 February 2007
- significant project applications should be submitted to CERFprojects@erin.gov.au by close of business on Friday 16 March 2007.

For further information, please email cerf@deh.gov.au or phone on 02 6274 2284.

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Feedback



HERE, as promised, are 10 runner-up entries in the Feedback New Year competition. We asked entrants to compose a text message in no more than 160 characters, sent by an alien who has just arrived on our planet. Some of last week's winning contributors sent more than one entry that we particularly enjoyed, and three of these are included here.

No sign of survivors. Died out 65 million years ago. No need for return mission.
Thomas J. Lynch, Perkasie, Pennsylvania, US

Natives wonderful. Send ketchup.
Chris Mullard, London, UK

Too late. Another one overrun by Starbucks.
Len Cooke, Wokingham, Berkshire, UK

"Green" site not safe, had to splash down at "blue" site. Life abundant and highly intelligent. Locals say dry land is bandit country – very dangerous.
Colin Wainwright, London, UK

Marooned! On Earth there is but one science. Based on mere observation and

logic, it forbids faster-than-light travel and our star drive is refusing to work.
Clive Bashford, London, UK

3rd planet-colonisation candidate. CO₂ rising and almost breathable.
John Alderson, Reading, Berkshire, UK

Anthropologists will have a field day here. They've got a creation myth that everything started with a "big bang". They've even got the math to prove it.
Michael Parsons, Canberra, ACT, Australia

It's life, Jim, but not as we know it.
Justin Byrne, Dublin, Ireland

Humans are not conscious beings but remote-controlled by little boxes pressed to the head or wires plugged into their ears.
Olaf Lipinski, Bad Homburg, Germany

This planet, mostly harmless, is chiefly remarkable for providing the best evidence so far that the limit of 160 characters on SMS messages is a universal const
Kim Bastin, Brunswick, Victoria, Australia

TURNING to other matters, reader Rex Last does not tell us how he came to be in possession of a Fibre Optic Musical Animated Fairy "of unknown provenance", but he does tell us that, despite being a retired professor of modern languages, he is baffled by the instructions that came with it for changing its bulb.

These read as follows: "Operating Synopsis. If the bulb not brightness, make use of the reserve bulb elucidate as follows: 1. Turn off electrical source. 2. Fetch out the lampholder. 3. Troll the broken bulb, fetch out of it. 4. Setting in reserve bulb, troll the bulb without a reel or stagger. 5. Revert the lampholder." Can anyone help?

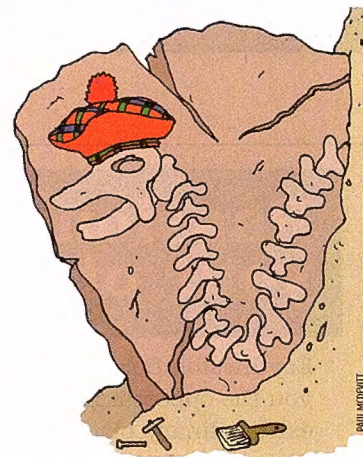
AUSTRALIA'S ABC radio carried a report by Barbara Miller on Stephen Hawking's recent proposal to set up space colonies to save the human species. John Ambrose has alerted us to the transcript of the report, which was put up on the ABC website, complete with an indication in brackets of the sound effects used. Here is an excerpt: "BARBARA MILLER: The trouble is that travelling at the speed of light... (Sound of light travelling)... really still is the stuff of fantasy." We would be really grateful if ABC could send us the audio file of this section of the report.

TOWARDS the end of last year, residents of the area around Colorado Springs, Colorado, suddenly found that the remote controls operating their garage doors had stopped working. The reason, according to an Associated Press item on AT&T Worldnet that Bashir Syed has alerted us to, was to do with national security.

Air force officials at nearby Cheyenne Mountain air station were testing a radio frequency they intended to use to communicate in the event of a homeland security threat.

What they hadn't bargained for was that the same frequency controls "an estimated 50 million garage door openers", AT&T Worldnet says – so hundreds of local people found they were reduced to opening their garage doors by hand.

"I never thought my garage door was a threat to national security," observed Holly Strack, one of those affected.



FINALLY, London's *Metro* newspaper has also been excelling in its science reporting: "One of the most complete plesiosaur fossils has been found in Antarctica," it informed us last month. "The skeleton of a baby reptile – which lived 70 million years ago... is thought to resemble the Loch Ness Monster."

Brian Russell, who spotted this, says it is nice to see *Metro* keeping its readers up to date with hard science.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

And then there is locational determinism. Greg Taylor has noticed that the Sydney office of Birds Australia is located in the suburb of Crows Nest

The last word

Last Words past and present, plus a full list of unanswered questions, are available on New Scientist's website at www.newscientist.com

WHEELS OF FORTUNE

Could hamster power be an environmentally friendly answer to the impending energy crisis? How many hamsters running on wheels would it take to provide energy for a house or a factory?

Thanks to everyone who pooled their physical, chemical and mathematical skills to calculate the impact of national or global hamster power. Sadly, no two people came up with the same figures. There is substantial disagreement even over the average weight of a hamster. Nevertheless, the conclusion reached by all correspondents is the same: The Last Word is a haven for hamster-power sceptics – Ed

● Let's assume a hamster weighing 50 grams can run up a 30-degree slope at 2 metres per second. This corresponds to a power output of half a watt. If it delivers the same power when running in a hamster wheel, we would need 120 hamsters working flat-out to light a 60-watt bulb.

The average hamster probably doesn't spend more than 5 per cent of its life running in its wheel, so already we need a brigade of 2400 hamsters just to light our bulb. It gets worse. The average UK household consumes in excess of 80 gigajoules of energy per year. This is equivalent to a constant power consumption of about 2.5 kilowatts. Each house would need 100,000 hamsters. Multiply this by the number of households in the UK and we would have an environmental and economic disaster.

In addition, we would need to employ an army of animal behaviourists to devise Pavlovian tricks to get the hamsters onto their wheels in response to surges in demand. And given that hamsters are nocturnal, this would force politicians and lawyers to debate animal welfare. The UK alone would need to employ everyone else in Europe to feed and care for its hamster population.

Perhaps we should let humans run on treadmills. It would not produce much electricity but we might end up with less of an obesity problem. *Mike Follows*
Willenhall, West Midlands, UK

● Hamsters running on wheels cannot relieve the impending energy crisis because animals are not energy sources – they are energy consumers. It would be more efficient to simply burn their food in a furnace and use the power output from that (a fact overlooked in *The Matrix* films, where humans are used as thermal energy sources by sentient computers).

John Woods
Stratford-upon-Avon, Warwickshire, UK

● According to the CIA website, the estimated global electrical energy consumption in 2003 was 15.45 trillion kilowatt-hours. To produce that kind of energy in ideal conditions would require around 1458 billion hamsters. Hamsters have an average lifespan of 2.5 years, meaning that if we had switched to hamster power in 2003, we would already have more than 2 billion tonnes of depleted hamster, and many backyard funerals. The environmental and socioeconomic impact of this would be devastating.

So it is my duty as a pseudotechnician to decree that this is another energy source best left to fiction.

Ben Padman
Perth, Western Australia

● The question is not whether hamster power is an environmentally friendly energy source, but whether it would be welfare friendly. As a veterinary student, I have spent some time looking at research into "the running wheel phenomenon". It is clear that captive hamsters are highly motivated to use running wheels. What mystifies researchers is why.

There is controversy over whether running-wheel activity is a stereotypic behaviour – repetitive, invariant behaviour with no obvious function

"Each house would need 100,000 hamsters to fulfil its power consumption needs"

(likened by some to obsessive-compulsive disorder in humans) which results from a suboptimal environment. Even if running-wheel use turns out not to be a stereotypy, there is further debate as to whether it corresponds to poor welfare, because such behaviours may merely be a way of coping with captivity.

However, what has been found is that when hamsters are given bedding 80 centimetres or more deep, which lets them indulge in natural burrowing behaviour, their use of running wheels drops dramatically and the performance of other stereotypies such as wire-gnawing ceases altogether. This suggests that we should reconsider how pet

hamsters are kept. Perhaps finding a way to harness the burrowing activities of hamsters would be a better solution to the energy crisis.

Sarah Briars
Shefford, Bedfordshire, UK

● Total world annual energy consumption is about 500 exajoules (an exajoule is 10^{18} joules). A hamster requires 15 grams of food per day. Let's assume that the hamsters eat wheat, with an energy content of 1400 kilojoules per 100 grams. If we assume that they convert the chemical energy of their food into useful energy with the same efficiency that power stations and wood-burning stoves do, some 6500 billion hamsters on wheels would be needed to supply the world's energy requirements.

Energy use in a typical house in the UK is about 80 gigajoules a year, which is the amount 1000 continuously running hamsters would produce. But worldwide hamster power would need 36 billion tonnes of wheat per year, nearly 60 times the present wheat production.

This exercise illustrates that the world's energy crisis is not simply due to excessive use of fossil fuels, which can be overcome by conversion to renewable energy sources. The scale of the conversion is far too great, and large-scale renewables have their downsides too. Cutting energy use through conservation and, by implication, a change in the way we live, is the main answer to the energy and climate change crisis. This is why politicians find it nearly impossible to confront the issue.

Philip Ward
Sheffield, South Yorkshire, UK

Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and a fax if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all answers that are published will receive a cheque for £25 (or the US\$ equivalent). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted

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(all correspondents should include their postal address in order to receive payment for answers). If you would like a complete list of all unanswered questions please send an SAE to LWQlist at the above address.

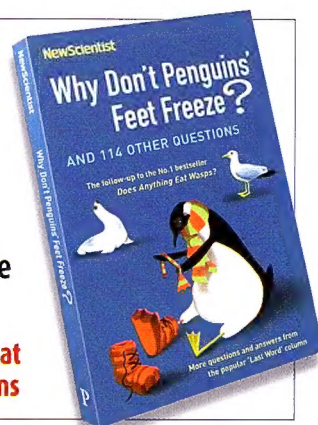
Memorable answer? As part of our 50th anniversary we have teamed up with Crucial Technology (www.crucial.com/uk) and will be awarding each successful author a 512MB Gizmo! overdrive.



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Marine conservationist Brad Norman can. He's developed a photo-identification system that identifies individual whale sharks from the unique set of spots on their skin, enabling him to chart their migratory routes and so aid their conservation. He's just one of the five 2006 Rolex Laureates whose groundbreaking endeavours have been selected by a panel of distinguished judges for their potential to expand human knowledge or improve the lot of mankind. The winners each receive a gold Rolex chronometer and US \$100,000 towards the completion of their projects. Which, for Brad Norman, will mean that one day we'll know where every whale shark's been just from its spots.

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